

Peabody, Massachusetts Trolley Feasibility Study

August 31, 2018

JACOBS®

Executive Summary

The City of Peabody, Massachusetts is interested in a possible trolley connection from Peabody Square to Salem Depot, two miles to the east. The Salem Commuter Rail Station offers 60+ passenger trains each weekday to North Station in downtown Boston with a typical travel time of 31 minutes. At this time the direct public transport service between Peabody and Boston are very limited, and Peabody's transit connections to Salem Depot are limited to the midday period. This study explores the potential to develop a rail transit connection between Peabody Square and Salem Station using an existing freight-only branch line running directly between the two locations. The study also considers how a bus on local roadways could be used in place of the rail shuttle.

Goals

It is hoped that a trolley connection to Salem Depot would stimulate new residential growth in Peabody and improve the quality of life for Peabody residents. Specific service goals include:

- Provide car-free transportation options for current and future residents of Peabody
- Leverage existing rail infrastructure and services
- Promote Peabody as a location for economic and residential investment
- Provide car-free reverse commute opportunities for people working in Peabody but living in other communities
- Promote connections between Peabody and neighboring communities

The study was crafted to address several questions and concerns raised by local officials related to market opportunities; development options; potential institutional, regulatory, environmental, and ownership issues; capital and operating costs; financial resources; potential service management/operators; potential benefits; and next steps.

Key Findings

1. The City of Peabody is the largest municipality inside the Route 495 ring that is not directly connected to the MBTA's commuter rail or rail rapid transit network.
2. The portfolio of transit services offered at Peabody Square does not effectively link Peabody with the region's urban core. There is only one peak round trip per day between Peabody Square and downtown Boston. Instead, local MBTA services generally focus on linking the North Shore malls with Lynn and Salem.
3. The rail line linking Peabody to Salem has offered more than 170 years of continuous service including 111 years of passenger service between Peabody and Boston, ending in 1958.
4. Nearby Salem Depot is the MBTA's most popular suburban station, with 2,400 inbound boardings each weekday.
5. Passenger service on the 2-mile rail line, linking Peabody with Boston via connections at Salem Depot, could be restored with a capital investment of approximately \$35 million.

6. A Peabody-Salem rail shuttle service could attract 600 boardings each weekday. At that level of patronage, the service would cover more than a third of its annual operating costs from passenger fares. The MBTA generally covers one-third of its operating expense from fare box revenues.
7. Pending a \$35 million investment in rail service, a dedicated shuttle bus route could be established between Peabody Square and Salem Depot. Although the bus shuttle trip would be 2 or 3 times longer than the rail shuttle trip, it should still attract a strong ridership response and demonstrate demand for a rail connection as the bus strengthens Peabody's ties to Boston's central core.

Recommendations and Next Steps

- Work with MassDOT, the MBTA, elected officials, and interested citizens to review and revise this plan as necessary. Reach out to the Town of Danvers to solicit their interest: while the "Peabody Trolley" is a seemingly attractive investment without Danvers' participation, Danvers' support and participation in service development would expand public support.
- Engage the MBTA concerning the current bus services offered to Peabody residents. The current portfolio of transit services offered in Peabody could be restructured to serve a wider array of travel markets and deliver more mobility to Peabody residents.
- After refining the findings of this preliminary feasibility study with the MBTA, seek funding (from MassDOT and the MBTA) to develop a dedicated bus shuttle between Peabody Square and Salem.
- Presuming that the bus shuttle proves to be a successful demonstration of the demand for premium transit service at Peabody Square, collaborate with MassDOT and MBTA to plan, fund and develop a rail shuttle linking Peabody Square with Salem Depot.

Table of Contents

Executive Summary	ES-1
Summary Report	SR-1
1. Introduction	1-1
2. Existing Conditions	2-1
3. Opportunities and Constraints	3-1
4. Service Alternatives	4-1
5. Evaluation of Alternatives	5-1
6. Next Steps	6-1

Acknowledgements

This study was managed for the City of Peabody by:

Curt T. Bellavance, AICP

Director of Community Development and Planning

City of Peabody, 24 Lowell Street, Peabody, MA 01960

With assistance from

- Brendan Callahan of the City of Peabody
- Lynn Ahlgren of Lynn Ahlgren Consulting

The study was prepared by Jacobs Engineering

- Dieckmann Cogill – Project Director
- David O. Nelson – Project Manager
- Beth Isler – Principal Planner

With assistance from

- Catherine Baisly – Track and Signals
- Gary Campbell – Rolling Stock Maintenance
- Alan H Castaline – Bus Operations
- Peter Cruz - Track and Signals
- Amanda DeGiorgi – Light Rail Rolling Stock
- William DeTore – Rolling Stock Maintenance
- Gavin Fraser – Rolling Stock
- Brian Moroney - Track and Signals
- Jon H. McPhail – Overhead Catenary
- Robert McPherson – Traction Power
- John J. Wilson – Bridges

Summary Report

The City of Peabody, Massachusetts is interested in a possible trolley connection from Peabody Square to Salem Depot, two miles to the east. The Salem Commuter Rail Station offers 60+ passenger trains each weekday to North Station in downtown Boston with a typical travel time of 31 minutes. At this time the direct public transport connections between Peabody and Boston are very limited, and Peabody's transit connections to Salem Depot are limited to the midday period. This study explores the potential to develop a rail transit connection between Peabody Square and Salem Station using an existing freight-only branch line running directly between the two locations. The study also considers how a bus on local roadways could be used in place of the rail shuttle.

1. Goals and Objectives

The study has two sets of goals and objectives: **Service Goals** related to changing the mix of mobility options available for travel to and from Peabody, and **Analytic Goals** related to informed decision-making concerning Peabody's infrastructure investment options.

1.1 Service Goals

Most travel and commuting in Peabody is made by automobile. Transit services available for Peabody travelers tend to be indirect, infrequent and slow. It is hoped that a trolley connection to Salem Depot would stimulate new residential growth in Peabody and improve the quality of life for Peabody residents. Specific service goals include:

- Provide car-free transportation options for current and future residents of Peabody
- Leverage existing rail infrastructure and services
- Promote Peabody as a location for economic and residential investment
- Provide car-free reverse commute opportunities for people working in Peabody but living in other communities
- Promote connections between Peabody and neighboring communities

1.2 Analytic Goals

The study was crafted to address several questions and concerns raised by local officials related to market opportunities; development options; potential institutional, regulatory, environmental, and ownership issues; capital and operating costs; financial resources; potential service management/operators; potential benefits; and next steps.

2. Existing Conditions

The study team documented existing conditions to understand the environment in which a trolley would operate. These conditions included demographics and travel patterns, railway services, other public transport services, railway conditions and potential funding support.

2.1 Demographics and Travel Patterns

Peabody is the largest community inside the Route 495 ring that is not directly served by the MBTA's rapid transit or commuter rail network. It is 20 miles north of Boston and has 52,000 inhabitants.

One motive for considering a trolley to link Peabody with the MBTA Salem Station is to provide more mobility options for households with limited access to an automobile and thereby promote Peabody, particularly the neighborhoods in the vicinity of the Square, as a location where a less automobile-centric lifestyle is feasible. One-tenth of the households in Peabody do not have access to an automobile for travel. More than a third of households have only one car available for travel. Barely half of households own multiple cars.

Focusing on the vicinity of Peabody Square, the study found that 4,353 housing units and nearly 9,000 inhabitants are within a 10-minute (1/2 mile) walk of Peabody Square. This constitutes approximately 20% of Peabody's population and housing.

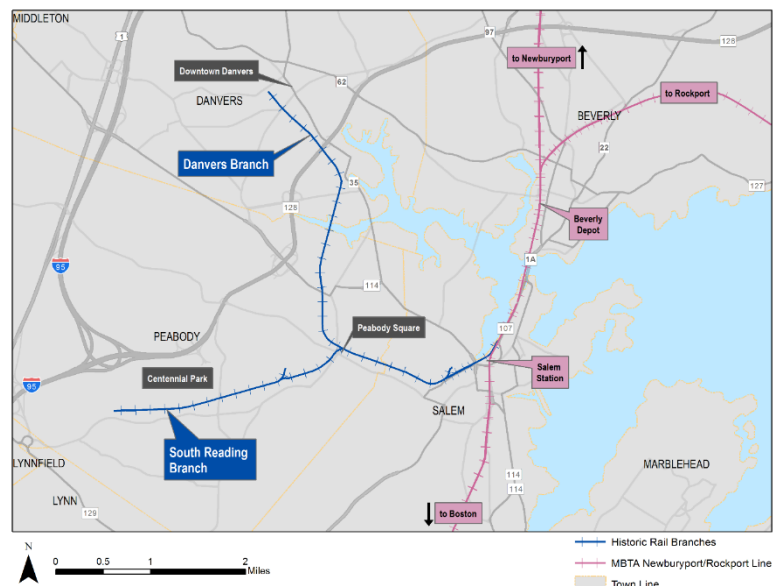
Peabody's active workforce includes almost 29,000 inhabitants. The greatest share (46%) of employed inhabitants work in Peabody and adjacent communities. Another 44% work in other suburbs of Boston. Only 2,700 (9%) travel to Boston or Cambridge.

Most Peabody residents working in Boston or Cambridge commute by highway. Only 9% of Boston and Cambridge commuters use the commuter railroad, which equates to 1% of Peabody's overall workforce. By comparison to communities that are a similar distance from Boston but have commuter rail service, the fraction of the workforce commuting by railroad ranges between 2% and 13%, with an average rate of 5%.

2.2 Railway Services

Three rail lines emanate from Peabody Square. The line running eastward connects the Square with Salem Depot. It is currently used as a freight branch line. The route northward is currently inactive but could be resurrected to extend the rail trolley service to downtown Danvers. A portion of the line running westward from the Square is also in active freight service. It could be refurbished to provide a rail trolley to the Centennial Drive commercial park.

The railroad first arrived in Peabody in 1847. All of the branches in town were operating by 1850 with direct passenger service to Boston. Over time, travel patterns and options changed, leading to reductions in service and eventual abandonment. Passenger service on the South Reading branch was discontinued to 1925. Passenger service on the Danvers Branch lasted until 1958.



Freight service to Danvers persisted until 1983 when a bridge fire closed that branch. Freight service between Salem and Peabody persists to this day with twice weekly service to an industrial customer on the South Reading Branch. Freight trains proceed at speeds below 10 mph on the unsignaled railway. The rail and tie conditions are good for a lightly used branch line. On the route segments that are not in active use, the rail and ties are generally extant. Based on a short inspection, the study team believes that much of the rail could be reused if the track were restored for rail trolley service. The ties would need to be replaced. The ballast and drainage would need a substantial renewal.

At nearby Salem Depot where Peabody's rail infrastructure connects to the mainline, the MBTA offers 60+ passenger trains each weekday to and from North Station in Boston, with a typical travel time of 31 minutes. According to an April 2016 ridership count, Salem is the MBTA's busiest suburban rail station with an average of almost 2,400 weekday inbound boardings.

2.3 MBTA Bus Services

Seven MBTA bus routes terminate at Salem Station's bus depot. A dedicated bus lane and a bus layover area was constructed with the garage in 2014. Only one of the seven Salem bus routes (Route 465) serves Peabody. It runs during the midday and evening hours only.

The bus services offered in Peabody are mostly oriented toward linking the Liberty Tree and North Shore Malls with Lynn and Salem via Peabody. The routes and their schedules have very limited utility for trips to and from Boston.

MBTA Bus Routes Serving Peabody					
Route	Description	Weekday Trips	PM Peak End to End travel time (Minutes)	Weekday Riders	Peabody Square Passenger Trip Ends
434	Peabody to Boston via Lynn	2	79	20	5
435	Liberty Tree Mall to Lynn via Peabody Square	31	57	350	134
436	Liberty Tree Mall to Lynn via Centennial Drive	31	54	660	N/A
465	Liberty Tree Mall to Salem Depot	25	44	330	150
Total		89	NA	1,360	289

Nearly 80% of all the passengers on the four routes serving Peabody get on and off at places other than Peabody Square.

2.4 Rapid Transit Service

A notable fraction of travel between Peabody and Boston occurs on MBTA's Blue Line, which runs from Revere to downtown Boston. Overall, 6,100 passengers board the Blue Line at Wonderland Station for a 19-minute trip to downtown Boston. According to the US Census, 180 of those boardings are made by Peabody residents commuting to Boston.

2.5 Railway Conditions

The line between Salem and Peabody is used to serve a single freight customer along the former South Reading Branch. The manufacturing plant receives shipments of approximately ten covered hopper and tank cars filled with commodities twice each week. For this level of traffic, the railway is maintained at

FRA Class 1, which is good for 10 mph maximum allowable freight speeds. Passenger service would require track upgrades to FRA Class 3, allowing speeds up to 60 mph.

The railway rights of way in Salem, Peabody and Danvers are all owned by the MBTA, which acquired the assets from the bankrupt Boston & Maine Railroad in 1964.

There are seven bridges over waterways on the three rail branches. Four lay between the Square and the Depot. Two are enroute to Danvers. Two are on the route to Centennial Drive. These bridges would need thorough inspections, evaluation and potential upgrades before passenger service could be restored. The Waters River bridge would need to be rebuilt before restoration of rail service to Danvers.

The railway crosses five streets at grade over two miles between Peabody Square and Salem Depot. Headed west from Peabody Square, towards Centennial Drive, the railway crosses nine additional roadways. Headed north toward Danvers the railway crosses four additional roadways. Any crossings that would host passenger traffic would need significant upgrades to the track structure and the provision of automatic highway warning devices (gates, flashers and bells) to reduce the risk of collisions between the rail vehicle and roadway users.

2.6 Funding Support

A very broad range of funding sources are used to defray the costs of public transport services in Massachusetts.

Local Funding

Under Massachusetts law, the City of Peabody is obliged to provide support for the operation of the MBTA. In FY2019, Peabody's contribution totaled \$1.16 million. Peabody might be able to leverage an ancient benefactor to help jump-start the trolley service: George Peabody, who was born in what was then "South Danvers" and for whom the City of Peabody was later named, was a successful entrepreneur and philanthropist who established a philanthropic trust in London during the 1860's. Today his Trust remains largely focused on its initial mission of providing housing for poor and working class residents of London, and has a value of \$7.8 billion. In the spirit of community development, the Peabody Trust might consider helping its founder's birthplace with a donation to seed an important public transportation and community development program.

State Funding

State funds are the most prevalent source of non-federal revenue to support the development and operation of public transport systems in the Commonwealth. Most funds for the MBTA and MassDOT derive from designated revenue sources such as the tax on gasoline, car sales, registry fees, tolls, or a portion of the sales tax. The MBTA's principal revenue sources include: statewide sales tax (51%), passenger fare revenues (32%), local assessments from cities and towns (8%) and non-passenger operating revenues (2%).

Peabody should expect that the Commonwealth and/or the MBTA would be the principal source of non-federal funding for development and operations of any Peabody passenger rail service. The MBTA would be the grantee and conduit for any federal funding.

Federal Funding

The Federal Transit Administration (FTA) administers the primary funding programs available for public transportation investments. Federal funding sources that the MBTA would mostly likely leverage to develop a Peabody Trolley Service are listed below.

Federal Funding Sources and Tools Potentially Available for Peabody Trolley Service Development				
Funding Source	Capital, Operations, Both	Eligible Mode	Formula/Competitive	Comments
FTA 5309 Capital Investment Grant (New and Small Starts) Program	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Competitive	For New Starts projects, CIG share capped at roughly 50 percent of capital costs; for Small Starts, cap is \$75 million. The Peabody Trolley is a logical candidate for a Small Start Grant.
FTA 5307 Urbanized Area Formula Grants	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Formula amounts, which are calculated based on metrics that included fixed guideway route and revenue vehicle miles, would increase following implementation of one of the commuter rail alternatives
FTA 5337 State of Good Repair (SGR) Grants	Capital	Light Rail Commuter Rail	Formula	After seven years of rail implementation
FHWA Surface Transportation Program (STP)	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Flexible for use by highway or transit projects
FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ)	Both	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Flexible for use by highway or transit projects
U.S. DOT Better Utilizing Investments to Leverage Development (BUILD)	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Competitive	Very competitive capital program Maximum award is \$25 M. The Peabody Trolley would be a logical candidate for a BUILD grant.

Fare Revenue

The operating and maintenance costs of each alternative will be offset by the fares collected from riders. The typical fare revenue per passenger mile for a light rail trip in Greater Boston is \$0.48. The typical revenue per passenger mile for a commuter rail trip is \$0.28.

3. Opportunities and Constraints

Based on the goals and objectives and the existing conditions, the study team mapped the aspirations of the goals and objectives onto the realities of existing conditions to help define reasonable service options.

3.1 Key Technological Considerations

Opportunities

- The rail line is in place and maintained for 10 mph freight operations.
- Current use of the line is limited to two freight round trips per week. This provides capacity for a passenger service.
- The track configuration at Salem Depot would provide for a convenient transfer to and from the commuter rail service at Salem without interfering with commuter rail train movements.
- Service to and from Boston's North Station at Salem Depot is very dense with 60+ trains each weekday. This creates many opportunities for coordinated transfers to and from Boston.

Constraints

- The rail line is single track, limiting opportunities for bi-directional traffic and reducing overall carrying capacity of the line.
- Five to thirteen grade crossings will require upgrades to support higher speed and higher frequency operations, depending on which alternative is selected.
- The railway crosses numerous bridges over waterways. All of the bridges that are crossed by the shuttle will require upgrades or replacement.
- The rail corridor between Salem and Peabody is subject to flooding when the Proctor Brook and North River swell with heavy rains. With sea level rise, the eastern portion of the rail route could be periodically inundated by high tides. Even now, storm surges affect the canal in Peabody Square.

3.2 Key Institutional Considerations

Opportunities

- The MBTA is committed to the support of rail passenger transportation.
- The current MBTA portfolio of services offered in Peabody does not include attractive options for work travel to Boston without using a private automobile to drive to the nearest MBTA rail station. This creates an impetus for change.
- The political and social climate in Eastern Massachusetts is conducive to change and investment related to living inside the Route 128 Ring and in established urban communities like Peabody.
- A possible extension of the trolley to Danvers would potentially increase support for new service by expanding the markets it would serve.

Constraints

- Federal regulations require a waiver and special operating procedures to use a rail vehicle that does not strictly comply with FRA standards on the rail line (e.g. electric light rail vehicle, lightweight self-powered rail car).

- The current use of the line for freight deliveries must be preserved.

Available discretionary funds at the state and federal level for the development of new passenger services is very limited. Competition for funding is intense.

3.3 Key Economic Considerations

Opportunities

- Together the MBTA and its contractor, Keolis Commuter Service, are a full-service passenger railway with access to the engineering, mechanical, transportation, and administrative resources necessary to design and operate a passenger service on the Peabody Branch.
- The passenger rail service would create meaningful options for transit-oriented development in Peabody Square, enhancing economic opportunities and quality of life for residents of Peabody.
- Extending the passenger rail service to Danvers could expand the options for transit-oriented development to a neighboring community.

Constraints

- Fiscal resources of local governments to directly develop and support the service are negligible.
- The backlog of proposed rail transit initiatives, including many State of Good Repair Projects for the MBTA and Greater Boston, is substantial.
- The debt load of the MBTA from previous transportation infrastructure investments is very high with more than \$400 million in annual debt service payments.

4. Service Alternatives

4.1 Rail Services

The study team developed and evaluated three rail route alternatives for connections to the MBTA's main line service between Salem Depot and North Station. In the interest of economy, all of the rail service alternatives were designed to operate with a single one-car train operating on a single track. Freight service would be scheduled to run overnight after the end of Peabody passenger service or in a slack midday window between passenger trains.

- **Peabody Shuttle** - 2 miles, 4 minutes, connecting with 36 MBTA trains to or from North Station each weekday. Two stations were assumed: a transfer station at Salem Depot and a Peabody Square station between Central Street and Wallis Street in Peabody. There are no intermediate stops between Peabody and Salem. Two variants on the Peabody Shuttle were developed: one diesel, the other electric.
- **Danvers Shuttle** - 5.1 miles, 10 minutes, connecting with 34¹ MBTA weekday trains to or from North Station. The diesel shuttle would run between the location of the former Danvers Station and a

¹ Due to the additional time needed to cover the increased distance to Danvers, this shuttle alternative would only be able to meet 34 trains instead of 36.

transfer station at Salem Depot, making intermediate stops at Danversport and Peabody Square. In the interest of efficiency, some peak trips were not scheduled to run all the way north to Danvers. Instead, they were terminated and turned at Peabody or Danversport so that they can return to make another connection at Salem Depot.

- **Centennial Shuttle** - 4.6 miles, 10 minutes, connecting with 34² weekday MBTA trains to or from North Station daily. This diesel shuttle would run between a terminal station at First Avenue and a transfer station at Salem Depot, making intermediate stops at Summit Street and Peabody Square. As with the Danvers Shuttle, some peak trips would be turned short of Summit Street to maximize service connections for Peabody Square travelers.

Rail Shuttle Service Summary

Shuttle Service	Peabody	Danvers	Centennial
Length (Miles)	2.0	5.1	4.6
Travel Time (Minutes)	4	10	10
Intermediate Stops	0	2	2
Weekday Peabody Connections to Boston	36	34	34
<i>Trip Durations b/w Peabody Square and North Station (Minutes)</i>			
Average	40	40	40
Minimum	33	36	36
Maximum	39	49	49

The rail service designs provide for a maximum allowable passenger train speed of 45 mph. Shuttle services would provide a five-minute connection time to Boston-bound trains and a three-minute allowance for load-and-go connections to trains from Boston. Regardless of which alternative is pursued, the train would consist of one car. Three types of rail rolling stock were considered.

Vehicle Options

Light Rail Vehicles (LRVs) - A one-car 200-passenger electric train would draw traction power from an overhead wire. In Boston, light rail is offered by the MBTA's Green Line and Mattapan services. Light rail trains in some locations share track with freight services. The principal advantages of LRV services are that the trains are quiet, nimble and light. The principal disadvantages are that LRVs require an off board source of motive power distributed by a cable suspended above the track. Federal safety regulations require stringent safeguards when LRVs share track with conventional rail freight services.



² Due to the additional time needed to cover the increased distance to Centennial Park, this shuttle alternative would only be able to meet 34 trains instead of 36.

Diesel Multiple Units (DMUs) – A one-car 200-passenger diesel train would be powered by a ~750 HP engine. Most modern US DMU services use cars designed for the European market. Since these cars don't meet all the safety requirements specified for sharing track with freight trains, an FRA waiver would be necessary. DMUs are often operated like light rail services when sharing track with freight services. A DMU can approximate LRV service while avoiding the cost of the electric catenary system.



Diesel Push-Pull (PP) represents the standard MBTA rolling stock for commuter rail operations. This rolling stock is fully approved for operation on tracks shared with freight operations. But compared with the light rail and DMU options, the much heavier push-pull trains cause more noise and vibration, offer slower acceleration, and use more fuel.



4.2 Bus Service

The bus shuttle would provide non-stop express service linking Peabody Square with Salem Depot via Walnut Street and Harmony Grove Road.

A bus depot used by all MBTA bus routes in Peabody Square could be developed to provide an attractive landmark and activity center. The T logo would be poised conspicuously on Central Street marking it the center for public transport in downtown Peabody. The shuttle vehicle would be a 40-foot bus drawn from the fleet of 96 buses based at the MBTA's Lynn Garage.



The bus travel time between the Square and the Depot would range between 7 and 12 minutes depending upon time of day and direction. Due to the longer running times on the roadway between Peabody and Salem, the typical transit trip between Peabody Square and North Station would be 46 minutes – 15% longer than the 40-minute rail shuttle travel time average.

Bus and Rail Shuttle Service Summary

Shuttle Service	Peabody Bus	Peabody Rail	Danvers Rail	Centennial Rail
Length (Miles)	2.0	2.0	5.1	4.6
Travel Time (Minutes)	7 to 12	4	10	10
Intermediate Stops	0	0	2	2
Weekday Peabody Connections to Boston	31	36	34	34
<i>Trip Durations b/w Peabody Square and North Station (Minutes)</i>				
Average	46	40	40	40
Minimum	39	33	36	36
Maximum	54	39	49	49

4.3 Potential Operators

With only one vehicle and one operator in service at any time, the Peabody Trolley would be a very small operation with no economies of scale. Regardless of the scale of the operation, a transit enterprise needs to provide training, spare crew and maintainers to cover vacations, absences, training, supervision, testing, administration, fare collection. A small standalone enterprise operating the Trolley would need to provide these functions internally or manage a network of subcontractors to provide the necessary support. In contrast, a larger existing transit operation could take on the Trolley more gracefully. These considerations lead the study team to recommend that the City of Peabody partner with established local rail and bus operating entities to operate and manage the service.

Massachusetts Bay Transportation Authority

The MBTA owns the rail right of way between Salem, Peabody Square and Danvers. It also manages all local passenger rail service in Massachusetts. The T operates the nation's largest light rail network and the fifth largest commuter railroad. The MBTA clearly has the experience, staff and resources to seamlessly absorb a 2- to 5-mile one-car rail shuttle or a 2-mile bus route into its portfolio of services with little duplication or additional overhead in providing management functions.

Private Contractors

Boston is fortunate to be home to two of the US' larger established passenger rail operators. Either of these two firms would be good candidates to support or collaborate with the MBTA to provide service. **Keolis North America** is the Western Hemisphere operation of a global public transport firm headquartered in France. It operates the commuter rail service of the MBTA as well as systems in 14+ other countries. **Alternate Concepts Incorporated** offers rail and bus transit services across the US. ACI's sister firm, Paul Revere Transportation, is Boston's leading provider of private shuttle bus operations.

5. Evaluation

5.1 Rail Service Capital Elements

Infrastructure and rolling stock investment that would be required for any of the rail service alternatives include:

- **Track** – Extensive track rehabilitation would be required. It is assumed that the rail could be salvaged and reused. New ties, ballast and drainage would be required. The extent of required rehabilitation would be somewhat less on the portions in active freight service.
- **Signals** – The shuttle service would be operated under non-signaled DCS operating rules. During passenger train hours, exclusive use of the track would be given to the shuttle. Track inspections and the freight train would operate during times when the passenger train service is suspended and locked behind one of the electrically-locked switches controlled by the train dispatcher. Automatic highway warning device signals would be necessary to warn motorists at the six crossings traversed by the passenger railroad. An allowance of \$150k per track mile is included for positive train control if federal regulators determine that it is required for this operation.

- **Stations** – Each platform would be approximately 100' long, 10' wide and 14" to 26" high depending upon the vehicle selection. The platform would include a 75' canopy, three benches, lighting, variable message signs, a public announcement system, and fare vending equipment. Up to 200' of 4'-wide walkways would connect passengers to nearby streets and commuter rail platforms.
- **Bridges** – All of the bridges carrying across waterways would require upgrades, rehabilitation or replacement.
- **Rail Vehicle Storage and Maintenance** – The DMU's or LRVs need a facility where they are stored, cleaned and maintained. The study team recommends a 120' long two-track building with a 22' paved center aisle for the movement of cranes, jacks and maintenance equipment to train side. A site for this facility would require a parcel at least 300' long and 65' wide to accommodate turn-outs and the building.
- **Electrification** – If an electric light rail car is selected for the Peabody Shuttle service, all passenger tracks would require electric wires suspended overhead, providing access to 600 Volt DC traction power. Electrification will also require a traction power substation to convert the electrical energy from the local electric grid to the 600 Volt DC current used to energize the overhead wires.
- **Vehicles** - The Peabody Shuttle would require one vehicle for daily operations with another held in spare reserve for maintenance and to respond to in-service failures.

5.2 Bus Service Capital Elements

Less extensive infrastructure and vehicle investment would be required for a shuttle bus service. The bus would use existing roadways shared with other automotive traffic and call on the existing modern bus depot at the Salem commuter rail station.

It would be possible that operations in Peabody Square could be staged on the street but an off-street location for buses to wait for the next trip and for passengers to pay fares, queue for buses and receive passenger information is recommended. The off-street location be would designed to be an attractive community landmark built on the publicly owned parcel where the two branches of the railroad split immediately east of Central Street. It would feature two bus berths, one for the rail depot shuttle and the other for existing MBTA routes. The bus platform would be sheltered with seating, fare vending equipment, variable message signs for passenger information and fully compliant with ADA and Universal Design guidelines.

- **Busway** – Approximately 700' of busway would be paved with curbs and drainage immediately north of the existing tracks.
- **Station** – The Peabody Transit Center would provide two connected bus berths with canopies, lighting, furniture and support equipment as described above.
- **Vehicle Storage and Maintenance** – The bus vehicles would be stored and maintained at the MBTA's existing Lynn Garage.
- **Vehicles** - The Peabody Bus Shuttle would require one vehicle for daily operations drawn from the MBTA fleet maintained in Lynn. A spare vehicle would be available when necessary from the pool of

spares at the Lynn Garage. Forecast capital costs for the four rail and one bus service options are summarized in the table below.

5.3 Capital Cost Estimates

The Peabody Rail Shuttle is forecast to cost \$34M to \$37M depending upon whether the trolley is diesel or electric. Extending a diesel rail trolley west to Centennial or north to Danvers would \$12M to \$16M to the costs for infrastructure upgrades. The costs do not include the acquisition of property on which to site a vehicle storage and maintenance facility or an electrical substation.

**Estimated Capital Expenditures
for Peabody Trolley Development Options (000's)**

Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
\$34,600	\$36,737	\$50,474	\$46,498	\$2,572

The bus shuttle would require much less capital expenditure. Investments would be limited to \$1.4M for a short busway and transit center. A new bus with an allowance for spares would add another \$1.1M.

5.4 Operating Cost

Four categories of operating cost are considered.

- **Transportation** – Operating crews with spares, dispatch, train control and fuel
- **Maintenance of Equipment (MoE)** – Labor and materials to maintain and clean vehicles
- **Maintenance of Way (MoW)** – Maintenance of track, drainage, crossings, bridges, switches, train control systems, stations, car barns
- **Administration** – Claims and legal, customer relations, security, payroll, revenue, purchasing, accounting and finance, human resources, training, safety and employee certification, etc.

The operating cost estimates in this report reflect only weekday operations. Weekend and holiday services would add significantly to the costs for transportation resources including crews and fuel and the costs for servicing rolling stock.

Transportation

Train Operators – Regardless of the motive power (diesel or electric), the one-car train would be operated like “trolley” cars with a single person crew. Forecast cost for staffing and supervision would be based on MBTA reported light rail (Green Line) transportation staffing expenditures per vehicle hour of service. (\$33.21)

Bus Operators – For the purposes of this cost estimate it is presumed that the MBTA would operate the Peabody-Salem Shuttle Bus. (\$31.97)

Propulsion Power – The fuel consumption rates and data sources for the various estimates vary with the mode. MBTA fuel costs for light rail electricity average \$0.52 per mile. MBTA bus fuel costs average

\$0.27 per mile. Fuel costs for five DMU fleets in Portland, New Jersey, California, Texas average \$0.35 per mile.

Maintenance of Equipment

The proposed shuttle services all reflect relatively low mileage duty cycles. But maintenance, including cleaning, inspections, and replacement of worn parts, will be required daily. Estimated MoE costs are based on annual reported MoE cost per vehicle for MBTA light rail (\$208,393), MBTA bus (\$111,540) and US DMU (\$233,193) fleets.

Maintenance of Way

Guideway Maintenance - It is assumed that maintenance for the track, bridges, highway grade crossings, signals and bridges would be assigned to MBTA commuter contract staff based in Lynn, Salem and Newburyport. It could be expected that one additional signal maintainer for all of the rail options and that one additional track or bridge and building maintainer would be required for the longer rail services.

Bus Infrastructure Maintenance - It is estimated that the bus berths and 700-foot busway recommended for the shuttle bus option would require two hours weekly to clear snow, sweep platforms, empty trash receptacles, clean graffiti, and change light bulbs, for a cost of approximately \$8,000 per year.

Electric Traction Maintenance –The study team estimates that adding a substation and overhead catenary system for an electric trolley would approximately \$208,000 to the Power Department’s annual expenditures.

Administration

The MBTA’s ratio of administrative support costs to direct operating expenditures is generally 15% and falls in line with general industry norms for the cost of claims and legal, customer relations, security, payroll, revenue, purchasing, accounting and finance, human resources, training, safety and employee certification.

Estimated Annual Operating Costs (000s)	Vehicle Operations	Vehicle Propulsion	Vehicle Maintenance	Guideway Maintenance	Power System Maintenance	Admin	Total Cost
Rail							
Peabody Shuttle Diesel	\$138	\$7	\$466	\$157		\$119	\$887
Peabody Shuttle Electric	\$138	\$10	\$417	\$157	\$208	\$143	\$1,072
Danvers Shuttle	\$139	\$17	\$466	\$307		\$148	\$1,078
Centennial Shuttle	\$139	\$16	\$466	\$307		\$147	\$1,076
Bus							
Peabody Salem Bus Shuttle	\$133	\$5	\$128	\$8		\$44	\$318

Asset Renewal – In addition to the cost of maintaining the capital assets necessary to operate the various shuttle options, funds should be set aside to replace or renew the track, signals, bridges and vehicles at the end of their expected lives. Based on the estimated costs and expected asset lives of the

various improvements that would be required, the annual suggested contribution to a “sinking fund” for each trolley service option is listed below.

Suggested Annual Asset Renewal Contributions (000's)

Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
\$568	\$713	\$1,150	\$1,055	\$46

5.5 Institutional and Regulatory Issues

Peabody will need to collaborate with MBTA to develop and operate any Peabody Trolley service. The T operates all of Peabody’s local bus service and manages the commuter rail service at Salem. It also owns the rail rights of way in Peabody, Salem and Danvers that would be used to develop and operate either the Peabody or Danvers rail shuttle service.

Pan Am is the freight railroad serving the North Shore on rights of way owned by the MBTA. It owns the rail rights of way west of Peabody Square towards Centennial Drive. Any rail shuttle will need to respect its rights and obligations to provide freight service under the “exclusive and perpetual freight easement” retained by its predecessor railroad - the Boston and Maine (B&M) - when the B&M sold most of its rail assets in Massachusetts to the MBTA in the 1960’s.

Under any circumstance, safety regulation for the line is the principal responsibility of the **Federal Railroad Administration**. The FRA is the lead safety agency for all general-purpose railroads in the nation. The FRA’s purview does not extend to local transit services like the MBTA’s Green and Blue Lines since they are not connected to the national network of conventional railroads. The FRA has stiff regulations regarding the design of rolling stock operated on the lines that it oversees. Light rail cars and light diesel cars do not meet those design criteria, but mechanisms and policies have been developed to allow light passenger cars to share track with freight operations on lightly used freight branch lines like the ones in Peabody.

5.6 Potential Ridership

Any of the proposed Peabody Trolley service alternatives would provide faster and more frequent transportation service between Peabody and downtown Boston. While this study did not have the time and resources to prepare a formal set of forecasts, the study team did prepare crude estimates of ridership potential. Should public officials choose to pursue development of a Peabody Trolley, more formal ridership forecasts should be prepared to vet the economic attractiveness of the service proposal.

The most conservative lower bound forecasts 1,212 weekday passengers on the Peabody Rail Shuttle. The Peabody Bus Shuttle would be somewhat less. Applying the estimated annual operating costs to the lower bound boarding forecasts indicates that the operating cost per passenger would lay in the range of \$1.08 to \$3.42.

Estimated O&M Cost per Passenger Trip	Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
Forecast Annual Passenger Trips	314,937	314,937	485,095	314,937	293,679
Forecast Annual O&M Cost (000s)	\$887	\$1,072	\$1,078	\$1,076	\$318
O&M Cost /Passenger Trip	\$2.82	\$3.41	\$2.22	\$3.42	\$1.08
Fare revenue per passenger trip	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00
Cost Recovery Factor	0.36	0.29	0.45	0.29	0.92

On average, the MBTA typically recovers one-third of its costs through passenger fares. Assuming that the average revenue per passenger trip on the Peabody shuttle would be \$1.00, the Peabody Diesel Rail Shuttle, the Danvers Rail Shuttle, and the Peabody Bus Shuttle would exceed the economic threshold of covering more than one third of their operating costs from passenger revenues.

6. Next Steps

2018

- Share the report with MassDOT and the MBTA and adjust the plan based on their feedback and concerns.
- Review the general findings and recommendations with elected officials and interested citizens.
- Share the report with the Town of Danvers. The “Peabody Trolley” is a seemingly attractive investment without Danvers’ participation, but Danvers’ support and participation in service development would expand public support.
- Engage the MBTA concerning the current bus services offered to Peabody residents. The current portfolio of transit services offered in Peabody could be restructured to serve a wider array of travel markets and deliver more mobility to Peabody residents.

2019

- Engage MassDOT to explore and refine the findings of this preliminary feasibility study. (This study was prepared in less than six weeks with a modest budget. More detailed analysis of ridership potential and bridge conditions would reduce uncertainty.)
- Seek funding from MassDOT and the MBTA to develop a dedicated bus shuttle between Peabody Square and Salem.

2020 or later

- Presuming that the bus shuttle proves to be successful demonstration of the demand for premium transit service at Peabody Square, collaborate with MassDOT and MBTA to plan, fund and develop a rail shuttle linking Peabody Square with Salem Depot.

1 Introduction

The City of Peabody, Massachusetts is interested in the potential of a trolley connection from downtown Peabody to the Salem Commuter Rail station. The Salem Commuter Rail Station offers 60+ passenger trains each weekday to North Station in downtown Boston with a typical travel time of 31 minutes. At this time there are no public transport connections between Peabody Square and the Salem station two miles to the east. This study explores the potential to develop a rail transit connection between Peabody Square and Salem Station using an existing branch line running directly between the two locations. Presently the branch is only used for freight deliveries but did support a substantial passenger service in the first half of the 20th Century.

This study was developed by first establishing project goals and objectives (Chapter 1) and assessing existing conditions (Chapter 2). The team then mapped existing conditions onto the goals and objects to identify opportunities and constraints related to establishing a rail or bus trolley service between Peabody Square and the Salem Commuter Rail Station (Chapter 3). Chapter 4 develops and describes five rail and bus service options responding to the opportunities and constraints. Chapter 5 evaluates the five service options, including capital and operating costs and ridership potential. Recommendations and “next steps” are described in Chapter 6.

1.1 Goals and Objectives

The study has two sets of goals and objectives. **Service Goals** related to changing the mix of mobility options available for travel to and from Peabody and **Analytic Goals** related to informed decision-making concerning Peabody’s infrastructure investment options. Both set of goals are discussed below

1.1.1 Service Goals

Most travel and commuting in Peabody is made by automobile. Transit services available for Peabody travelers tend to be indirect, infrequent and slow. The City is interested in developing a new rail transit option focused on connections to a nearby premium transit service that would be much faster than driving to Boston and Cambridge. It is hoped that this new rail service would stimulate new residential growth in Peabody and improve the quality of life for Peabody residents. Specific service goals include:

- Provide car-free transportation options for current and future residents of Peabody
- Leverage existing rail infrastructure and services
- Promote Peabody as a location for economic and residential investment
- Provide car-free reverse commute opportunities for people working in Peabody but living in other communities
- Promote connections between Peabody and neighboring communities

1.1.2 Analytic Goals

The study is intended to inform local leaders concerning their options for making transport investments that meet the Service Goals. In particular, the leaders seek information and advice on the following topics:

- **Market Opportunities** – How do Peabody residents, employees and visitors current travel? How could a rail transit investment potentially change their travel behaviors by providing a new faster route to the hub of the regional economy?
- **Development Options** – How could the existing rail line be used to provide connections with the commuter rail service in Salem? What other services could be developed to advance the project’s service goals? Expansion of service to other communities? Rubber-tired alternatives? Direct service to Boston?
- **Project Issues** – What institutional, regulatory, environmental, and ownership issues would implementation of a potential rail service.
- **Capital Costs** – How much capital investment in right of way, vehicles, stations and facilities would be required?
- **Operating Costs** – How much would day-to-day operation of the service option cost?
- **Financial Resources** – What funding sources beyond the coffers of the City of Peabody would available to support the capital and operating expense of the service.?
- **Potential Service Management/Operators** – Who might Peabody partner with to develop and operate the service? What is the recommended path forward for development and operation of the service?
- **Potential Benefits** – How would the service benefit Peabody and the Commonwealth with new transport options, changed travel behaviors, stimulated residential and economic development.
- **Next Steps** – What steps are recommended to develop the recommended service option(s)? What would be the likely timeline for development?

2 Existing Conditions

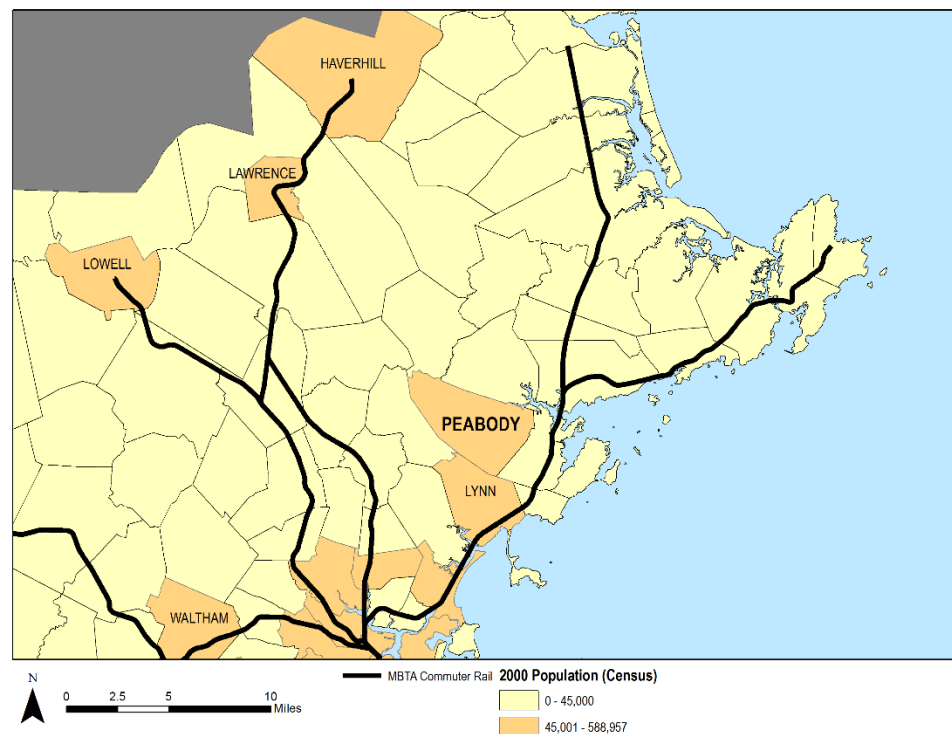
This chapter documents existing conditions to establish an understanding of the environment in which a trolley would operate. This chapter examines:

- Demographics and travel patterns
- Railway services
- Other public transport services
- Railway conditions
- Funding support

2.1 Demographics and Travel Patterns

With nearly 52,000 inhabitants Peabody is 25th most populous municipality in the Commonwealth. Lying 20 miles north of Boston, it is the largest community inside the Route 495 ring that is not directly served by the MBTA's rapid transit or commuter rail network (Figure 1). This portion of the feasibility study reviews the demographics and

Figure 1: North Shore Commuter Rail Service and Population

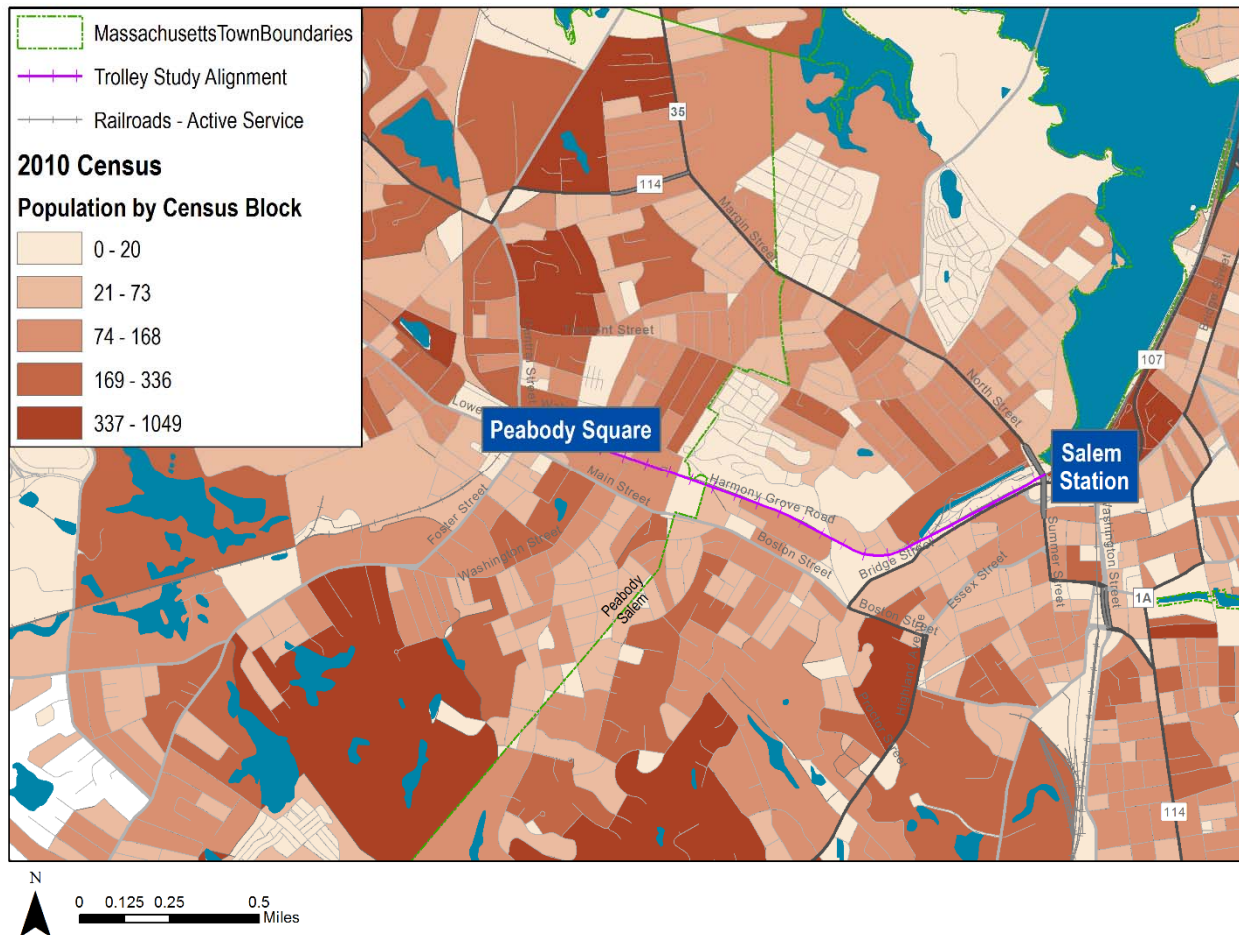


travel information that helps define the market for a prospective passenger rail service between Peabody and Boston via a connection at Salem. It uses US Census data and other online sources to describe population density, vehicle availability, household composition, and travel patterns of Peabody relative to its neighbors and peers.

2.1.1 Population density

The density of development near Peabody Square is substantial. As shown in Figure 2, there are two very dense census blocks approximately ½ mile south of the Peabody Square.

Figure 2: Population by Census Block (source: 2010 Census)



2.1.2 Vehicle Availability

One tenth of the households in Peabody do not have access to an automobile for travel. More than a third of households have only one car available for travel. Barely half of households own multiple cars.

One motive for considering a trolley to link Peabody with the MBTA Salem Station is to provide more mobility options for households with limited access to an automobile and promote Peabody, particularly the neighborhoods in the vicinity of the Square, as a location where a less automobile-centric lifestyle is feasible. With a trolley in walking distance, couples and families would have the realistic option to live with only one (or no) car as one member of the household walks to trolley for transport employment in the regional central business district.

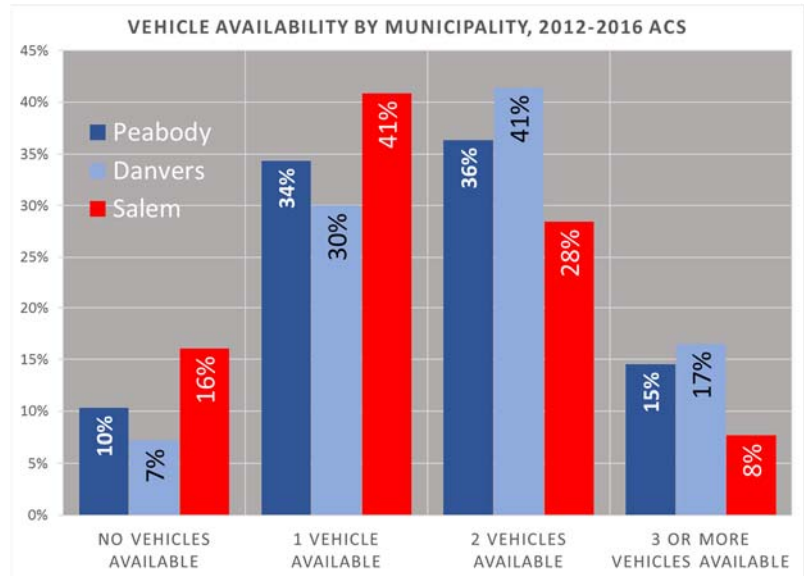


Figure 3: Vehicle Availability (source: 2012-2016 American Community Survey)

Detailed information concerning automobile availability is shown in Table 1 and Figure 2.

Table 1: Study Area Vehicle Availability Distribution (automobiles per household) (source: 2012-2016 American Community Survey 5-year Estimates)			
	Zero	One	More than one
Peabody	10%	34%	55%
Salem	16%	41%	43%
Danvers	7%	30%	63%

2.1.3 Household Size

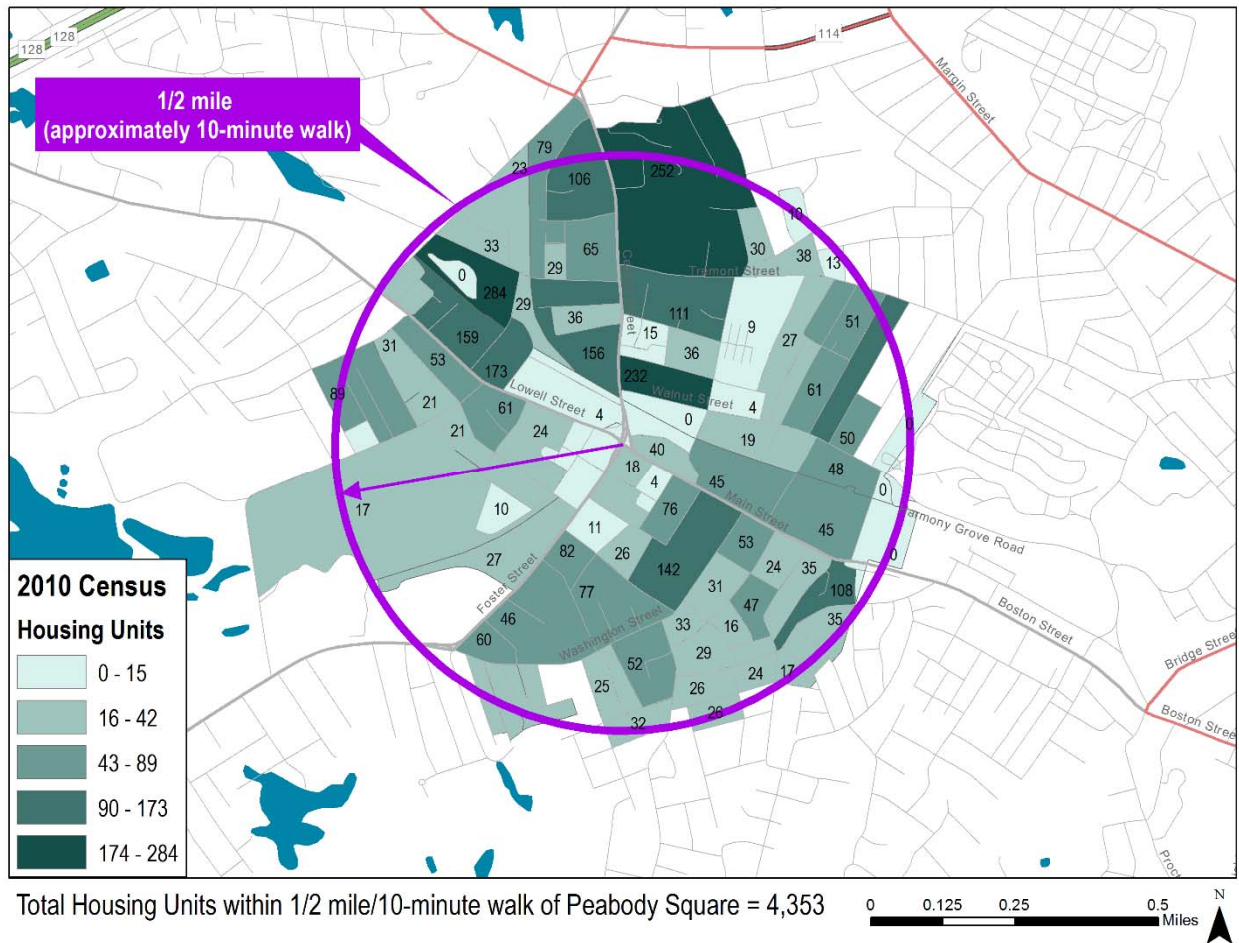
Peabody's 52,000 residents inhabit 21,500 distinct households for an average household size of 2.4 persons. Almost 20% of Peabody's population is over the age of 65. There will be many new residents in Peabody of the next 10 to 20 years.

Table 2: Household Size (source: 2012-2016 American Community Survey 5-year Estimates)						
	Total Population	# of Households	Average Household Size	# of 1-2 Person Households	% of 1-2 Person Households	People 65+
Peabody	52,235	21,504	2.40	12,600	59%	10,908
Salem	42,804	18,070	2.26	11,705	65%	5,721
Danvers	27,558	10,543	2.54	6,415	61%	5,445

2.1.4 Housing and Population within a 10-minute walk of Peabody Square

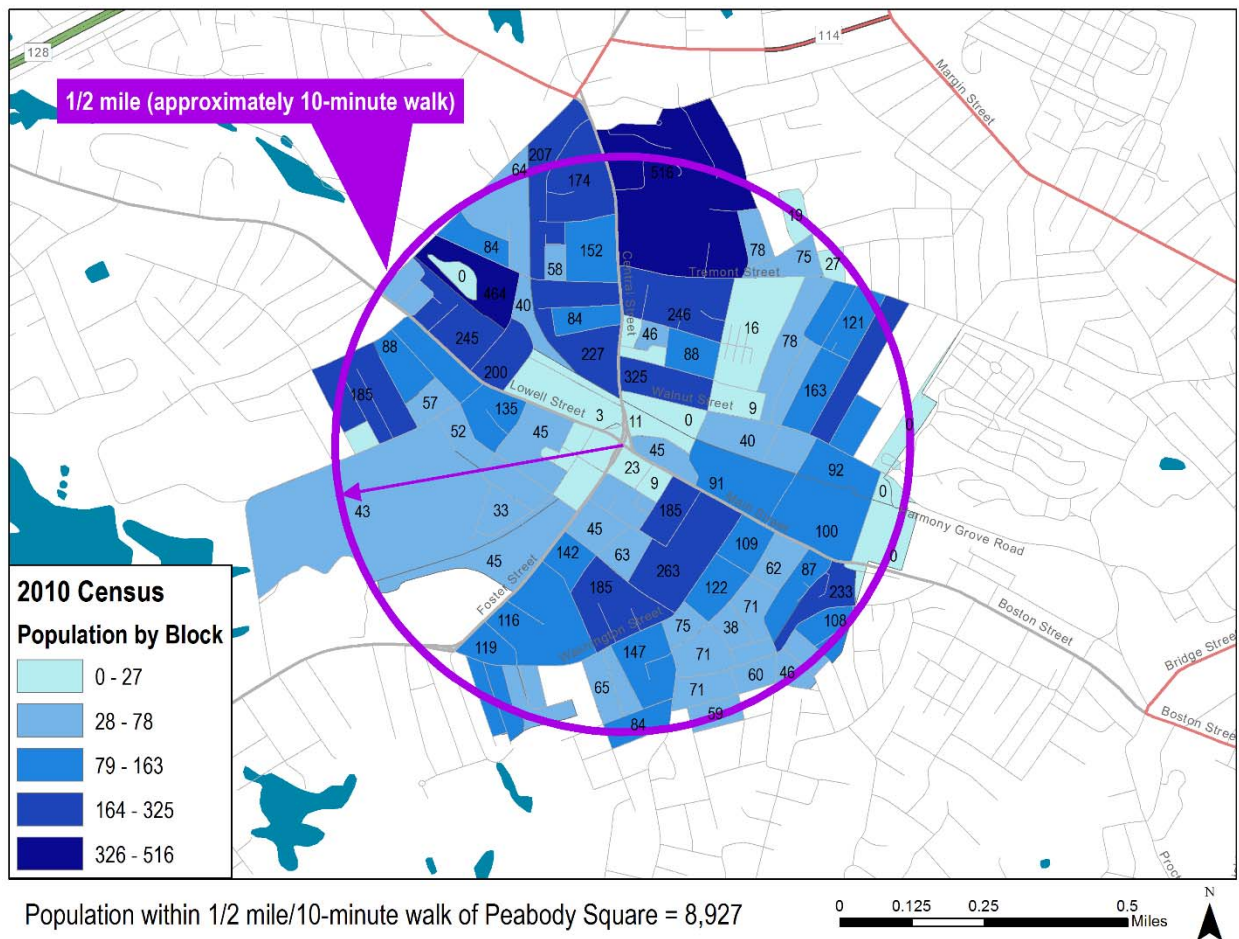
In considering the potential size of a walk-in market for a Peabody Trolley, the study team paid particular attention to the density and nature of residential development within a half-mile of Peabody Square. In total, 4,353 of Peabody's 21,504 housing units are within a 10-minute (1/2 mile) walk of Peabody Square. This constitutes 20% of the housing in the community.

Figure 4: Number of Housing Units within 1/2 mile of Peabody Square by Census Block (source: 2010 Census)



Nearly 9,000 people live within a ten-minute walk of Peabody Square, constituting 17% of Peabody residents.

Figure 5: Population within 1/2 mile of Peabody Square by Census Block (source: 2010 Census)



2.1.5 Peabody Workforce and Commute Patterns

Among Peabody's 52,000 inhabitants almost 29,000 are active in the workforce. The greatest share (46%) of employed inhabitants work in Peabody and adjacent communities. Another 44% work in other suburbs of Boston. Only 2,700 (9%) travel to Boston or Cambridge.

Most Peabody residents working in Boston or Cambridge commute by highway. As shown in Figure 6, 70% of Peabody residents commuting to Boston or Cambridge drive alone to work. An additional 12% carpool.

Table 3: Work Locations of Employed Peabody Residents (source: 2006-2010 American Community Survey 5-year Estimates)					
	Total Workforce	Work in Peabody	Work in Adjacent Community ¹	Work Elsewhere	Work in Boston or Cambridge
Number	28,851	6,470	6,875	12,811	2,695
Percent	100%	22%	24%	44%	9%

¹ Salem, Beverly, Danvers, Lynn, Lynnfield

Public transport constitutes 18% of the commuter market with 8% (225 workers) traveling via commuter rail through Salem Depot, 7% (180 workers) driving to the Blue Line in Revere, and 3% (75 workers) traveling by bus. The low transit mode share for commuter travel to Boston seems to reflect the quality of transit options available to local residents.

Peer Comparison -As the largest community inside the Route 495 ring without MBTA rail service, Peabody's travel patterns and the employment destination choices of Peabody residents are skewed in comparison with other communities in Greater Boston. Travel to Boston and Cambridge for work has never been more popular and the highways connecting outlying communities to Boston and Cambridge have never been more congested.

Figure 7 compares Peabody's travel patterns to Boston with other communities within 17 to 25 miles of Boston. Unlike Peabody, each of these "peer communities" has commuter rail service to Boston. Like Peabody, the peers' peak highway travel times² to Boston average between 58 and 111 minutes depending on variability in roadway conditions, fluctuations in demand and resulting congestion delays. But each of these peers also have a commuter rail option for travel to Boston with travel times generally well below peak highway travel times.

Peabody Resident Commute Mode to Boston and Cambridge: 2016
 N=2,695

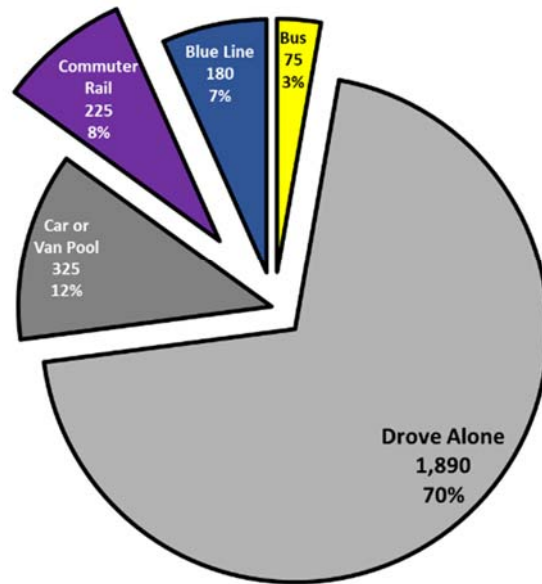


Figure 6: Commute Mode of Peabody Residents who Work in Boston or Cambridge (source: 2016 Journey to Work)

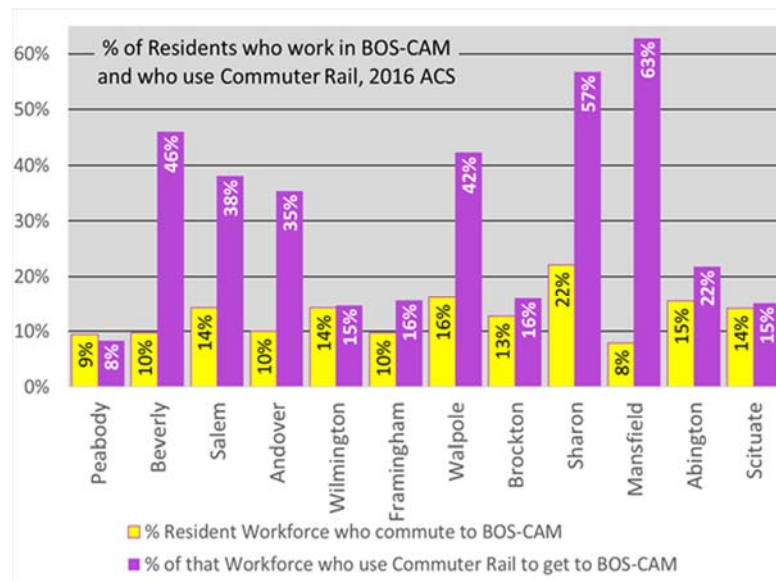


Figure 7: Percent of residents who work in Boston or Cambridge AND use commuter rail (source: 2016 ACS)

² Source: Google Map lookups for 8:30 highway arrival in Boston in August 2018

Table 4: US Census Journey to Work Information for Peabody and Peer Municipalities

Municipality	Miles to Boston	AM Peak Highway Minutes to Boston		Commuter Rail Minutes to Boston	% of Workforce Employed in Boston or Cambridge	% of Boston and Cambridge Employees using Commuter Rail	% of Total Workforce Commuting by Rail
		Min	Max				
Peabody	20	55	100	0	9%	8%	1%
Peer Group Average	20	58	111	40	13%	35%	5%
Beverly	18	60	100	36	10%	46%	4%
Salem	17	50	110	32	14%	38%	5%
Andover	23	55	100	50	10%	35%	4%
Framingham	21	50	90	52	10%	16%	2%
Walpole	19	60	110	42	16%	42%	7%
Brockton	20	60	130	34	13%	16%	2%
Sharon	18	55	110	35	22%	57%	13%
Mansfield	25	65	120	42	8%	63%	5%
Abington	19	55	120	32	15%	22%	3%
Scituate	23	65	120	48	14%	15%	2%
Peer Group Maximum	25	65	130	52	22%	63%	13%
Peer Group Minimum	17	50	90	32	8%	15%	2%

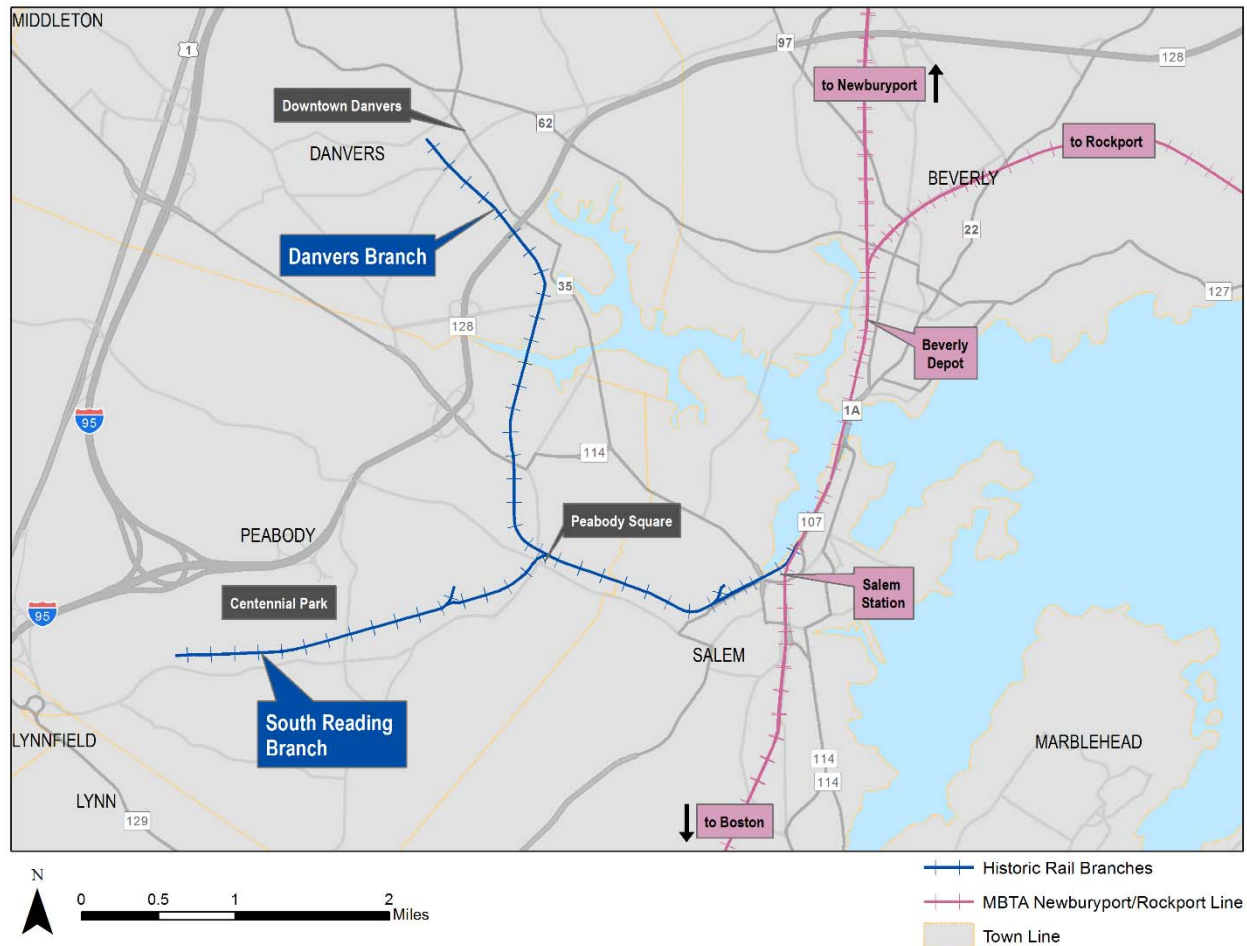
The availability of commuter rail for the peers has a demonstrable impact on the workplace options and travel choices of residents, as shown in Table 4. Among employed Peabody residents, 9% of the workforce commutes to Boston or Cambridge, with only 8% of those workers using the commuter rail station in Salem for their travel. The net effect is that only 1% of Peabody's workforce is commuting on the railroad. By comparison, the peer communities with commuter rail service have a larger fraction of their workforces commuting to Boston and Cambridge and within that portion, a larger fraction traveling by railroad. Among the peers, the average portion of the workforce working in Boston or Cambridge is 13%, with more than one-third travelling by railroad. On average, 5% of the workforce in these communities use the railroad to commute to work.

This peer comparison suggests that with a rail connection to Salem and North Station, the portion of Peabody residents working in Boston or Cambridge would increase by 50% and that the fraction of workers commuting on the railroad would increase five-fold.

2.2 Railway Services

This section describes the historic and current rail lines in the study area, as shown in Figure 8. Three rail lines emanate from Peabody Square. The line running eastward would connect the Square with Salem Depot. The route northward is currently inactive but could be resurrected to extend the rail trolley service to downtown Danvers. A portion of the line running westward is active freight service. It could be refurbished to provide a rail trolley to the Centennial Drive commercial park in Peabody.

Figure 8: Historic and current rail lines



2.2.1 Historic Railway Services

The railroad first arrived in Peabody in 1847 when the Essex Railroad built a two-mile line from Salem. Several competing railroads constructed lines to Peabody during the golden age of railway investment and expansion. While never on one of the heavily travelled main lines, four branches converged in downtown Peabody.

1. The first leg of the Essex Railroad line ran eastward 2 miles from Peabody Square to Salem, where it met the Eastern Railroad's main line between Boston, MA and Portland, ME. The Eastern Railroad absorbed the Essex line in 1851. Regular direct passenger train service ran between Peabody and Boston via Salem until 1958. Scheduled times on this segment between Peabody and Salem were generally seven minutes. This branch is still in active freight service, owned by the Commonwealth and maintained and operated by Pan Am Railways.



1910 North Shore Rail Network

2. The second line ran northward from the Square to Danvers, three miles away. This continuation of the Essex Railroad was completed in the 1850's. From Danvers, some passenger trains continued northward to Lawrence, MA. But all service between Danvers and Lawrence was abandoned in 1927. Passenger service between Danvers and Boston via Peabody continued but ridership and service frequency dwindled until 1958 when the passenger service was abandoned. Scheduled travel times on this segment between Peabody and Danvers were generally 10 minutes. Freight rail service between Peabody and Danvers continued until 1983 when the rail bridge over the Waters River burned. The rail right of way between Peabody and Danvers is owned by the Commonwealth but has not been active in 35 years.

The Boston and Maine Railroad (B&M), which acquired the Eastern Railroad in 1884, operated the lines leading to Salem and Danvers as one

service. In 1909, the B&M operated up to 28 passenger trains per day between Boston, Peabody and Danvers. Eight of these trains extended to Lawrence. The rest terminated in Danvers. The running time between Peabody and Boston was generally 42 minutes. By 1926, the number of daily trains between Boston, Peabody and Danvers was reduced to 18. Service on this branch to Lawrence was suspended. By 1945 the number of weekday trips was reduced to 14 with a station added between Danvers and Peabody at Danversport. By 1954, the Danversport Station no longer appeared in the timetable and the number of weekday trains had dwindled to six.



1926 North Shore Railway Network

3. The third line ran northeasterly from Peabody Square toward North Reading, Andover, Tewksbury and Lowell. It was a portion of the “Salem and Lowell Railroad” that opened in 1850. The line remained intact for 75 years when western portions of the route were abandoned by the B&M. Additional sections were abandoned in the ensuing decades until the last few miles of the route between Peabody Square and West Peabody were abandoned in 1962.

Passenger service on this branch was always spotty. In 1926, only six regularly scheduled passenger trains used this route: four to Lowell and two to Lawrence and Haverhill. All passenger service along this line was abandoned in 1932.



1945 North Shore Rail Network

4. The last line ran more easterly to Lynnfield and Wakefield. This “South Reading Branch” opened in 1850 to provide direct passenger service from Salem and Peabody to Boston via Wakefield. But it proved to be a redundant asset as the region’s smaller railroads were consolidated into a unified B&M network. The B&M’s South Reading branch west of Peabody was abandoned in 1925. Route 128 in Lynnfield was built over the rail right of way. Today the eastern most mile of the route is still in active freight service. The South Reading Branch in Peabody is owned by the Pan Am Railway. Since this branch had not seen passenger trains since the 1920’s it was not of interest to the MBTA when it acquired most of the main lines of the B&M railroad in 1976. Today the line maintained by the Billerica-based Pan Am Railway.

This short-lived route was called the South Reading Branch, since when it opened the Town of Wakefield had not yet separated from Reading. In 1909, the 9-mile overall route between Salem and Wakefield enjoyed 12 trains on the typical weekday, making only three stops (Peabody, Lynnfield and Montrose). But the service was no longer economic 16 years later when the last passenger train ran between Salem and Wakefield.

2.2.2 Current Railway Services

Today, 2.8 miles of the former route between Salem and Wakefield is in active service bringing commodity shipments in covered hopper and tank cars to a plant on Allens Lane in Peabody. Rousselot receives two bulk commodities that it uses to manufacture a wide variety of gelatin products for the

photographic, pharmaceutical, edible protein and food/confectionery industries. The factory generally receives two short (~10-car) trains each week. Investments have funded increases in storage capacity, that will allow the plant to receive fewer but longer trains, reducing the rate of train movements to one per week.

The portions of the railway between Salem and Rousselot are in active service and maintained for freight deliveries. Operations proceed at speeds below 10 mph on the unsignaled railway. A summary inspection of the railway indicated that the rail and tie conditions were good for a lightly used branch line. The study team understands that the railway condition was recently improved when Rousselot began receiving tank cars of HCL. This hazardous commodity is corrosive. In contact with the atmosphere the concentrated forms release acidic mists that are dangerous to the skin, eyes, or internal organs.

On the route segments that are not in active use, the rail and ties are generally extant. Based on a short inspection the study team believes that much of the rail could be reused if the track were restored for rail trolley service. The ties would need to be replaced. The ballast and drainage would need substantial renewal.

There is no passenger service on the remaining tracks in Peabody. But in nearby Salem where the branch connects to the mainline, the MBTA offers 60+ passenger trains each weekday to and from North Station in Boston, with a typical travel time of 31 minutes. The principal object of this study is to explore Peabody's options for developing a rail transit service that would connect to the busy and popular service offered at Salem.

Located off Bridge Street near the intersection of Massachusetts Route 107 and Route 114 just north and east of downtown Salem, Salem Station is served by Newburyport/Rockport Line. Salem station has one platform on a single track at the northern entrance to a short tunnel that carries the railway under downtown Salem. A staircase provides the most direct passenger access between downtown and the trains where the railway passes under Bridge Street (Route 107). Passengers can park their cars in a 715-space garage that opened in 2014. According to an April 2016 ridership count, Salem is the MBTA's busiest suburban rail station with an average almost 2,400 weekday inbound boardings.

The railway line to Peabody connects to the MBTA mainline north of the station along an arc. This arc would make direct service from Peabody to Boston very problematic since trains moving from the Peabody branch to the mainline enter the main facing in the same direction as trains to Newburyport and Rockport. The possibility of a direct connection to Boston was eliminated when the new parking garage was constructed.

Seven MBTA bus routes terminate at Salem Station's bus depot. A dedicated bus lane and a bus layover area was constructed with the garage in 2014.

Route	Destination/Origin	Typical Weekday Boardings (2012)
450	Haymarket	1,785
450W	Wonderland Station	
451	North Beverly via Cabot Street or Tozer Road	163
455	Wonderland via Central Square, Lynn	2,103
456	Central Square, Lynn via Highland Avenue	324
459	Downtown Xing via Logan Airport & Central Square, Lynn	1,184
465	Liberty Tree Mall via Peabody & Danvers	414

Only one of the seven Salem bus routes (Route 465) serves Peabody. It runs during the midday and evening hours only.

2.3 Other Public Transport Services

2.3.1 MBTA Bus Service

As noted earlier, Peabody is the largest community inside the Route 495 Ring that does not enjoy MBTA rail service. The bus services offered in Peabody are mostly oriented toward linking the Liberty Tree and North Shore Malls with Lynn and Salem via Peabody. The design of the routes and their schedules have limited utility for trips to and from Boston. (Figure 9). Instead the services generally focus on local travel around the North Shore to serve the mobility needs of transit dependents. The overall ridership is light with very few trips oriented toward commuter travel or attracting travel by persons with travel options.

Figure 9: MBTA Bus Routes that serve Peabody

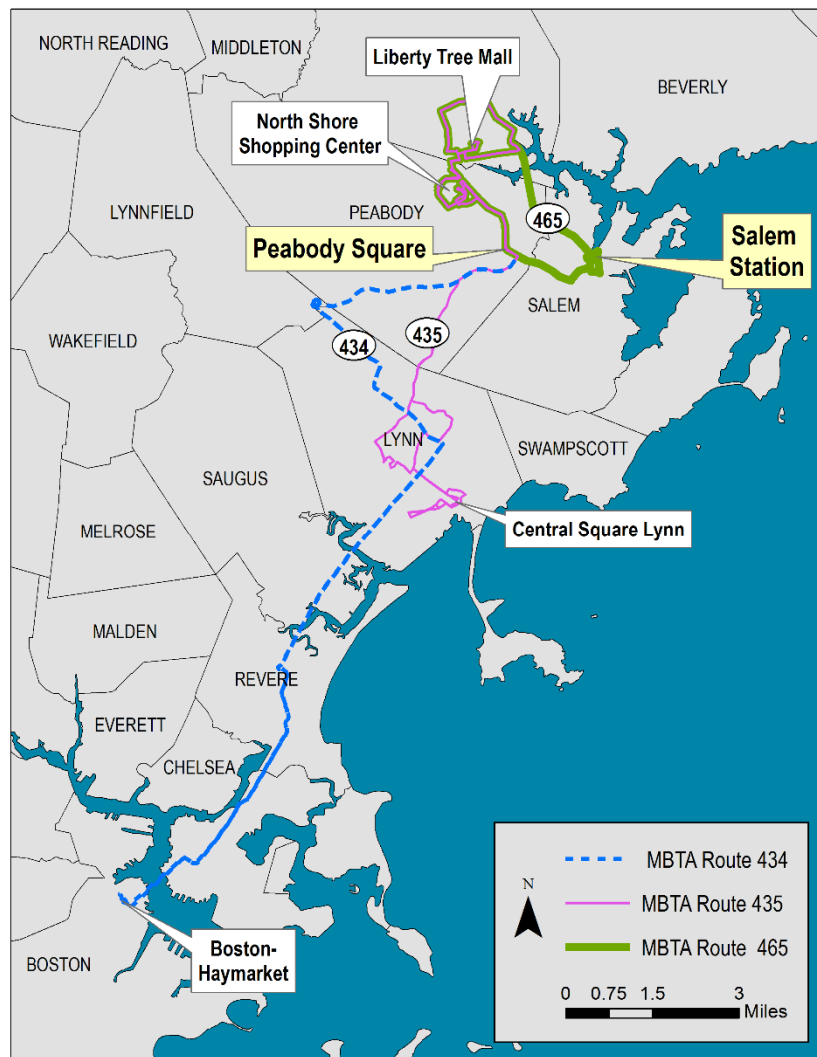
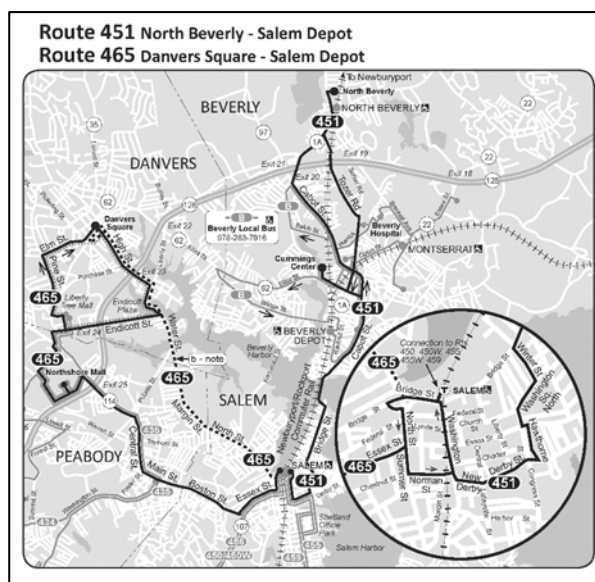
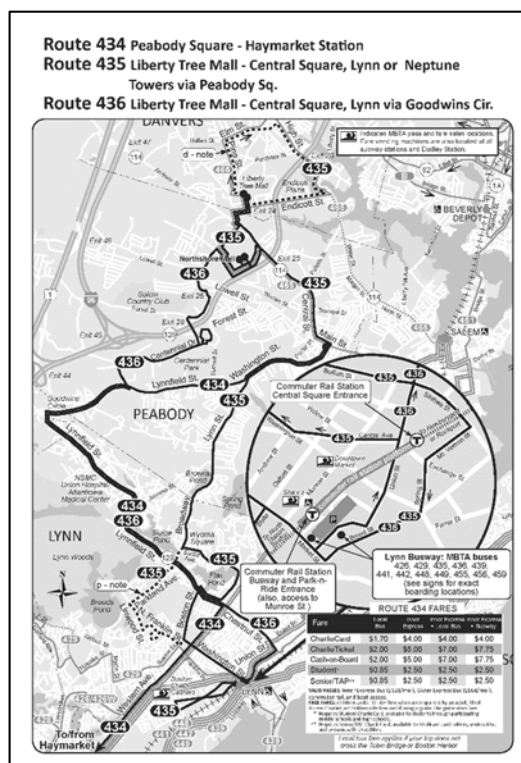


Table 3: MBTA Bus Routes Serving Peabody

Route	Description	Weekday Trips	PM Peak End to End travel time (Minutes)	Weekday Riders ³	Peabody Square Passenger Trip Ends
434	Peabody to Boston via Lynn	2	79	20	5
435	Liberty Tree Mall to Lynn via Peabody Square	31	57	350	134
436	Liberty Tree Mall to Lynn via Centennial Drive	31	54	660	N/A
465	Liberty Tree Mall to Salem Depot	25	44	330	150
Total		89	NA	1,360	289

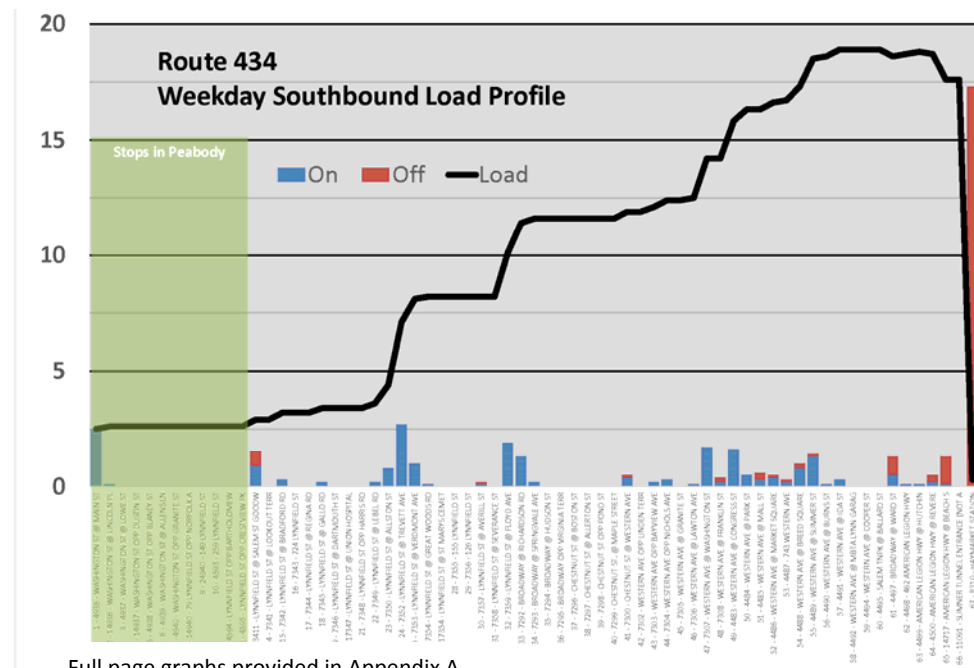
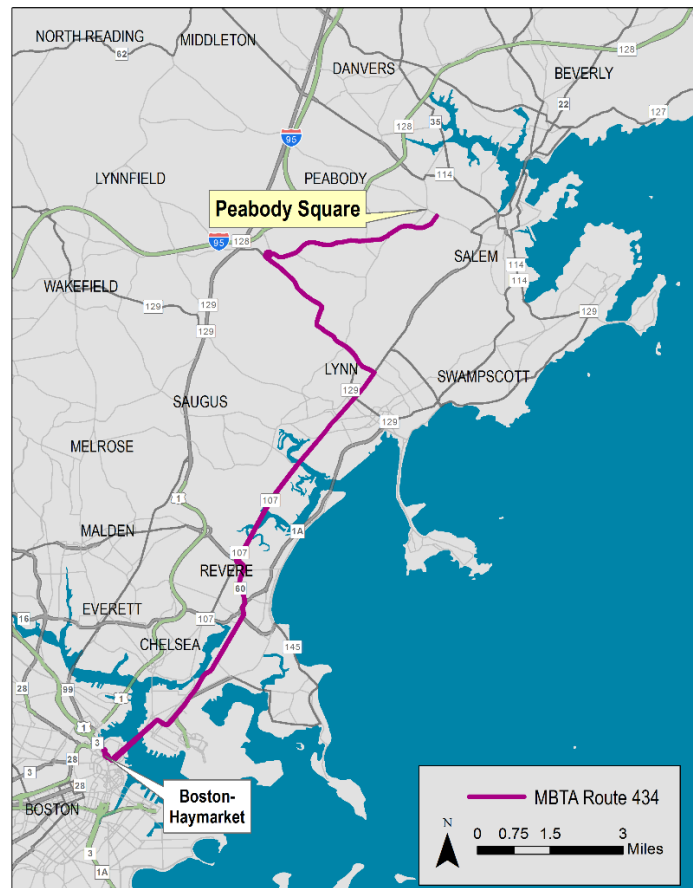
The four MBTA bus routes that serve Peabody are staged from the MBTA's Lynn Garage and tend to reflect an era when Lynn was the economic centroid for transit travel on the North Shore. Nearly 80% of the total passenger traffic on the four routes serving Peabody get on or off at places other than Peabody Square. Each of the routes is described below.



³ MBTA Planning and Scheduling Data from 2017.

Route 434: Peabody-Boston Express - This limited regional service connects Peabody and Boston, via Lynn. It is considered an Inner Express Bus Route. But it makes only one round trip each weekday arriving at Haymarket at 8:00 am with a return trip leaving Haymarket to 5:20 pm. The inbound trip is scheduled to take 45 minutes. The outbound trip is scheduled for 70 minutes of travel time. In 2013, the route carried 30 inbound passengers and 30 outbound passengers on a typical weekday⁴. Route 434 does not operate on weekends.

The graph below shows the pattern of southbound boardings and alightings along the typical trip in 2017⁵. In 2017 the typical daily ridership was approximately 40 total passengers (20 in each direction). Blue bars in the figure indicate boardings at each scheduled stop, while brown bars reflect alightings. The load on the route (boardings minus alightings) is depicted by the black line. Stops in Peabody are highlighted in



Full page graphs provided in Appendix A.

green.

The maximum daily load on Route 434 is somewhat fewer than 20 passengers.

It is notable that fewer than 3 passengers per day board Route 434 in Peabody. Most board in Lynn.

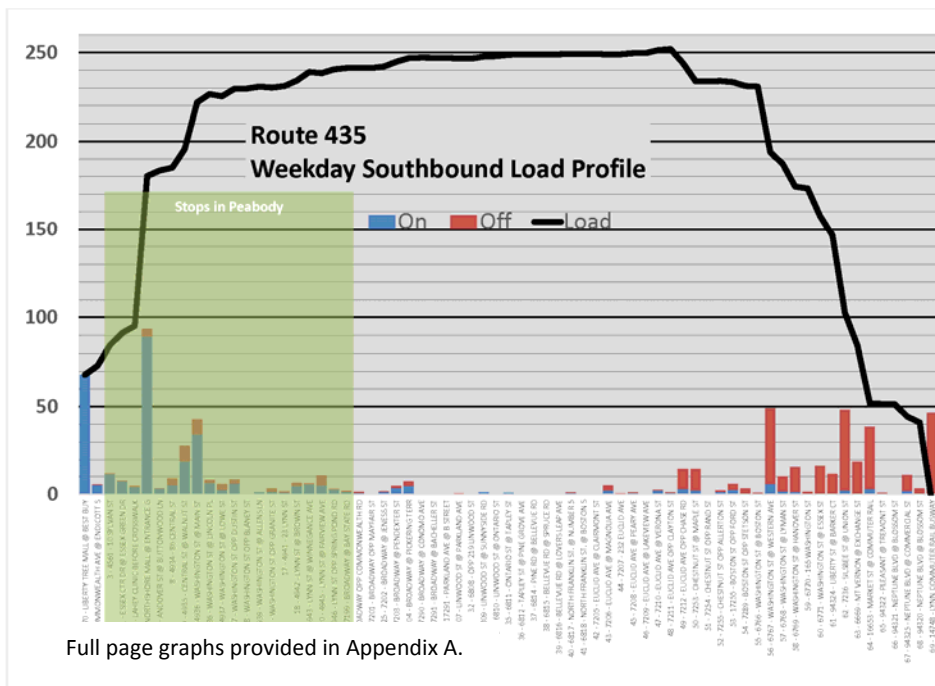
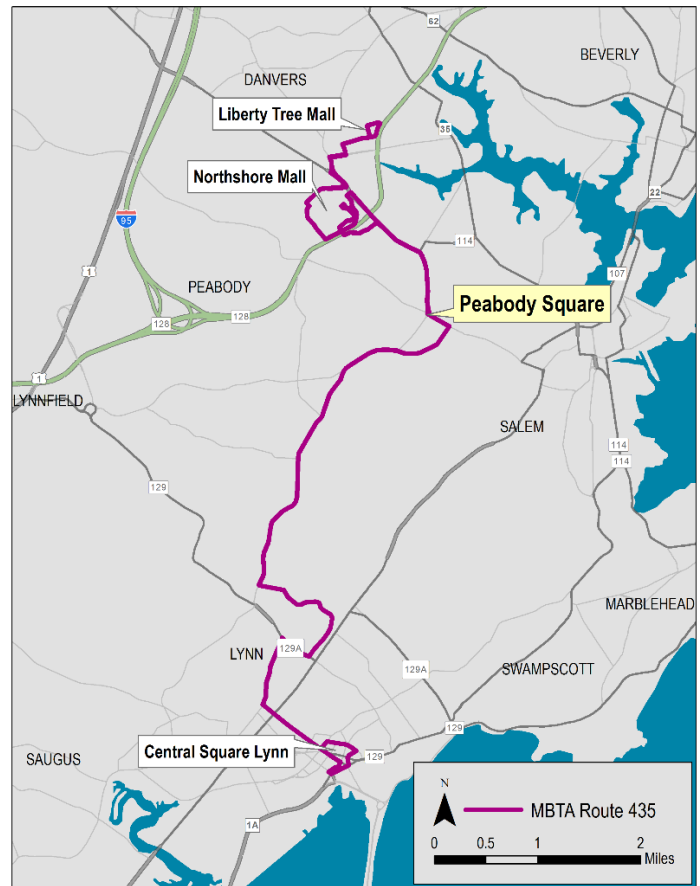
⁴ 2014 edition of MBTA *Ridership and Service Statistics* ("The Blue Book")

⁵ 2017 data provided by MBTA Plans and Schedules Department in August 2018.

Route 435: Lynn to Shopping Malls via Peabody Square - Route 435 connects the shopping malls in Danvers and Peabody to downtown Lynn via Peabody Square. It makes 16 southbound/inbound trips and 15 northbound/outbound trips on weekdays. On Saturdays, it makes 14 trips in each direction and on Sundays it makes 7 trips in each direction.

In 2013, the route was reported carrying 912 passengers on weekdays, 744 on Saturdays and 385 on Sundays.

The graph below shows the pattern of southbound boardings and alightings over a typical day in 2017. In 2017 the typical daily ridership has dwindled to approximately 700 total passengers. Blue bars indicate boardings at each scheduled stop, while brown bars reflect alightings. The load on the route (boardings minus alightings) is depicted by the black line. Stops in Peabody are highlighted in green.



The maximum daily load on Route 435 is approximately 250 passengers. Nearly all of the passenger trips are Lynn residents accessing the Peabody and Danvers Mall.

As can be seen in the load profile most of the southbound travelers on Route 435 board at the malls and ride through to Lynn. The same pattern is observed for northbound travel.

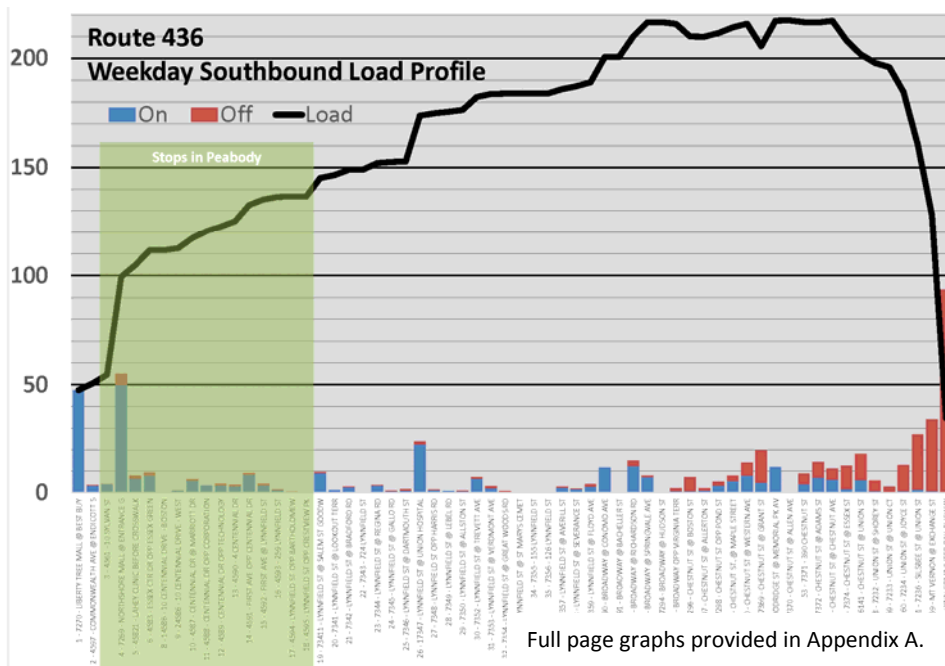
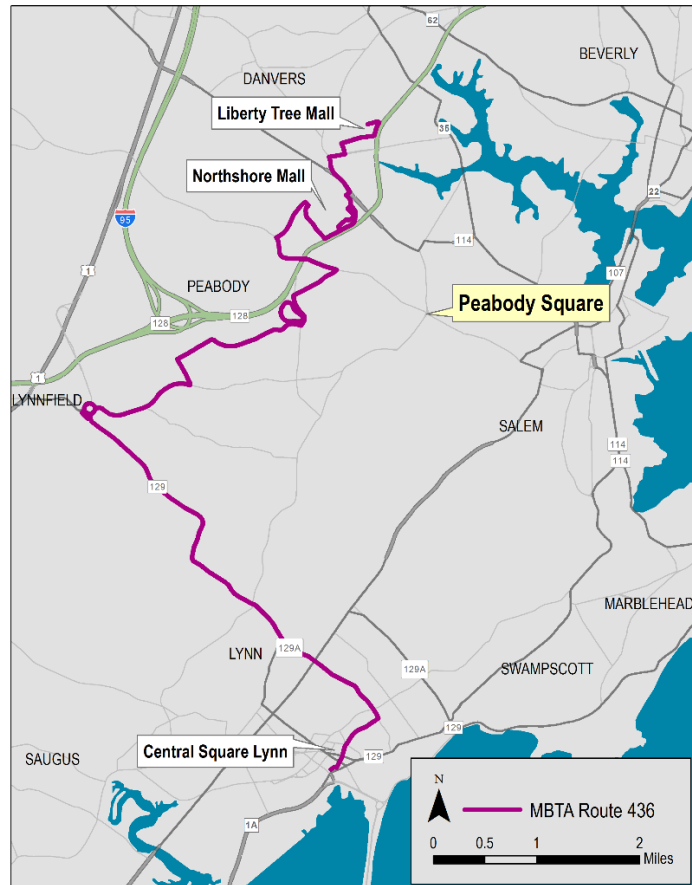
Route 436: Lynn to Shopping Malls via Centennial Drive - Like Bus 435, MBTA

Route 436 connects the shopping malls in Danvers and Peabody to Lynn, but via a more westerly route, including a segment along Centennial Drive.

During a typical weekday, it makes 15 southbound/inbound trips and 16 northbound/outbound trips. It makes ten trips in each direction on Saturdays but does not operate on Sundays.

In 2013, the route was reported carrying 823 passengers on weekdays and 527 on Saturdays.

The graph below shows the pattern of southbound boardings and alightings over a typical day in 2017. In contrast to the 2013 ridership of 823 passengers, the 2017 data show a typical daily ridership of only 660 total passengers.



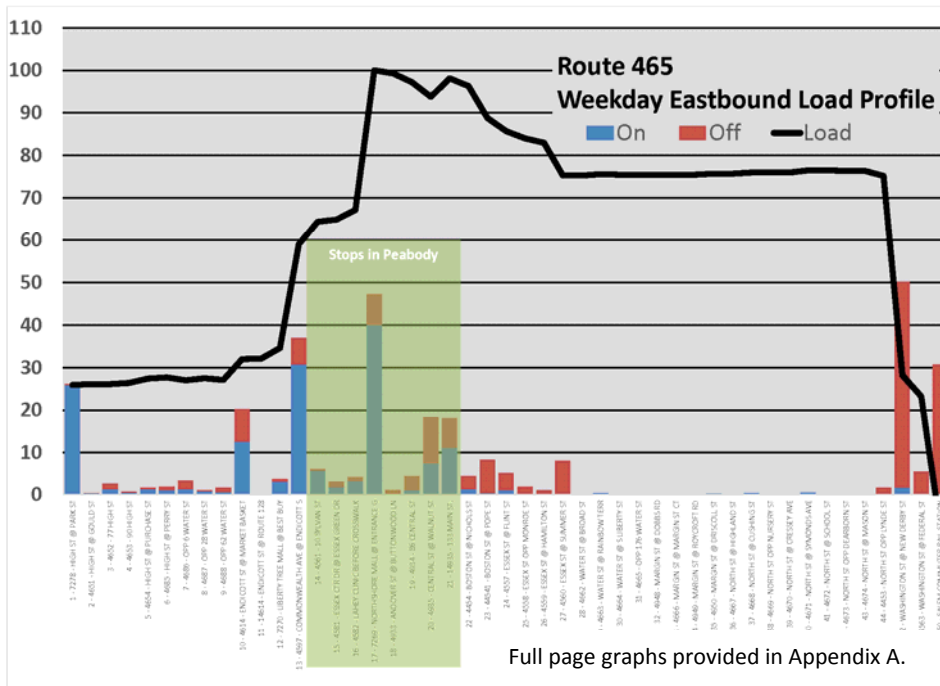
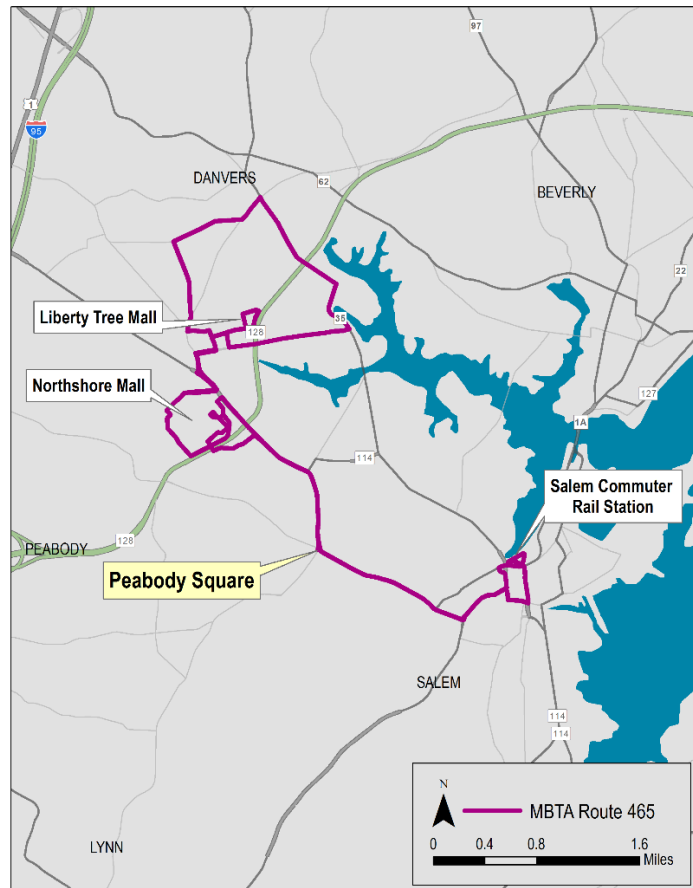
The maximum daily load on Route 436 is approximately 220 passengers in downtown Lynn.

Like local route 435, most travelers use route 436 for travel between the malls and residences in Lynn. But compared to route 435 there is more intra-Lynn travel between the outskirts of the city and its core.

Full page graphs provided in Appendix A.

Route 465: Liberty Tree and Northshore Malls to Salem Station – Route 465 is a local service connecting the shopping malls with Downtown Salem via Peabody Square. It makes 13 inbound/eastbound trips and 12 outbound/westbound trips each weekday, but the first two trips in the morning and last trips in the evening bypass Peabody to provide a direct commuter connection between Danvers Square and Salem Depot for connections to the commuter railroad service. The commuter trips between Danvers and Salem Depot are scheduled for a duration of 14 to 18 minutes depending upon time of day and carry only 20 passenger trips per day. In 2013, the overall route was reported carrying 414 passengers on weekdays and 267 on Saturdays. There is no Sunday service.

The graph below shows the pattern of eastbound boardings and alightings over a typical day in 2017. In 2017, the typical daily ridership has dwindled to approximately 330 total passengers.



The maximum daily load on Route 465 is approximately 100 passengers just east of the Northshore Mall.

The route has fewer than approximately 40 daily passenger boardings in Peabody Square; twenty westbound toward the malls and twenty eastbound toward Salem.

Full page graphs provided in Appendix A.

2.3.2 Blue Line at Wonderland

In addition to the local bus service that directly serves Peabody and the commuter rail that can be accessed in nearby Salem, a notable fraction of travel between Peabody and Boston uses that MBTA's Blue Line that runs from Revere to downtown Boston.

Table 4: MBTA Blue Line metrics from Wonderland (source: 2014 MBTA Blue Book)			
Travel Time to Boston (minutes)	Typical Weekday Passenger Boardings	Typical Daily Boardings by Peabody Commuters	Headways (Time Interval between trains)
19	6,105	180	Rush Hour: 5 minutes Midday/Evening: 9 minutes Late Night: 13 minutes

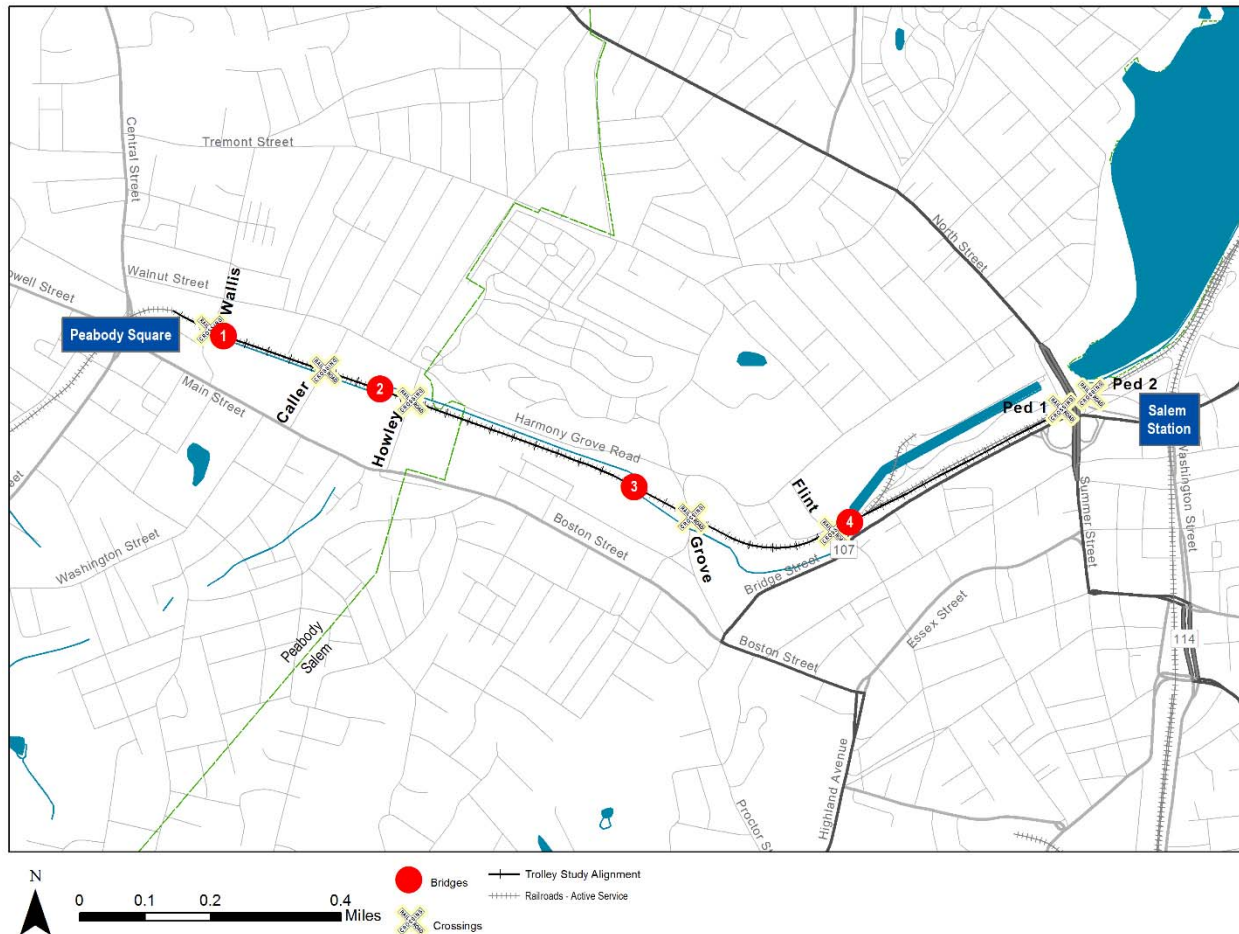
2.4 Railway Conditions

As noted above, Peabody once enjoyed extensive passenger rail service to Salem and Boston. But by 1958 with the rise of the automobile, the economics of the service and railroad had shifted, resulting in the end of passenger service. Today the line between Salem and Peabody is used to serve a single freight customer along the former South Reading Branch. The manufacturing plant receives shipments of approximately ten covered hopper and tank cars filled with commodities twice each week. The freight train serving Peabody originates in Boston running to a switch north of Salem Depot. The freight train backs onto the Peabody Branch and parks on a short siding that allows its engine to "run around the train" reversing its position from trailing to leading as the train heads up the branch. After it serves the customer the local freight backs down the branch to the mainline connection for Salem where it backs onto the main and heads (engine ahead) back toward Boston.

A canal runs parallel to the tracks and crosses them at four points. There are four bridges, five roadway crossings, and two pedestrian crossings along the study alignment, as shown in Figure 10. The following sections describe the track conditions, bridges, crossings, and abandoned tracks.

It should be noted also that the rail corridor between Salem and Peabody is subject to flooding when the Proctor Brook and North River swell with heavy rains. With sea level rise, the eastern portion of the rail route could be periodically inundated by high tides. Even now, storm surges affect the canal in Peabody Square.

Figure 10: Bridges and Crossings along the Study Alignment



2.4.1 Track conditions

The local freight service has kept the rail branch alive and kicking. A preliminary field inspection found that the was in better condition than might be expected. Regular delivery of heavy cars to Rousselot requires sturdy bridges and serviceable track. Tie conditions visible from the streets of downtown Peabody were good. The jointed rail and had few noticeable defects. Spot rail replacement, ballast and surfacing would seem to be sufficient to start a light rail connecting service to Salem.

2.4.2 Right of Way

Most of the railway rights of way in Salem, Peabody and Danvers are owned by the Commonwealth which acquired the assets from the bankrupt B&M in 1976. Pan Am owns the rights of way west of Peabody Square towards Centennial Drive. These 19th century railways are generally on a 30' right of way. In many locations along the line, the railroad property is wider than 30' where there were sidings, abutments and support structures. A 30' right of way is barely sufficient for the construction of a two-track railway. According to the City of Peabody Assessor's Office parcel data, the line to Salem at its narrowest point is approximately 30'.

2.4.3 Bridges

The rail line between Peabody Square and Salem Depot crosses the North River/Proctor Brook four times on short single-track bridges.

West of Peabody Square enroute to Rousselot, the railway crosses Proctor Brook on a short timber bridge just south of Lowell Street.

North of Peabody Square enroute to Danvers, the railway crosses the Waters River and Cranes River on two bridges. The Cranes River Bridge is extant.

The existing bridges in Salem, Peabody and Danvers would need a thorough inspection, evaluation and potential upgrades before passenger service could be restored. The Waters River bridge would need to be rebuilt before restoration of rail service to Danversport and Danvers Square.

Summary information concerning the seven bridges in Salem, Peabody and Danvers is presented below.

1. **Bridge 1.85** - Just west of **Lowell Street** in Peabody Square the railway to Rousselot crosses the North River/Proctor Brook canal on a 50' timber open deck bridge.



2. **Bridge 1.78** - Just east of **Wallis Street** near Peabody Square, the railroad crosses the North River/Proctor Brook canal on a short single-track bridge approximately 20' long. The ties are directly affixed to iron I-beams supported by concrete abutments. A plaque under the bridge indicates that it was built in 1914. A preliminary estimate for improving the bridge for passenger rail service is \$50,000.

Bridge east of Wallis Street



Bridge east of Wallis Street



3. **Bridge 1.48** - Two hundred and fifty feet west of **Howley Street** in Peabody, the railroad crosses the North River/Proctor Brook canal on a single-track bridge approximately 35' long. The ties are directly affixed to wooden beams supported by stone abutments. It is possible that this bridge might be able to be replaced with a box culvert, costing roughly \$300,000.

Bridge west of Howley Street



Bridge west of Howley Street



4. **Bridge 1.10** - Five hundred feet west of the **Grove Street** highway bridge in Salem, the railroad crosses the North River on a single-track bridge approximately 35' long. The ties are directly affixed to wooden beams supported by stone abutments on the banks of the river and two wooden piers in the river bed. This bridge appears to be in relatively good condition for passenger rail service.

Bridge west of Grove Street



5. **Bridge 0.73** - One hundred and fifty feet east of the **Flint Street** highway bridge in Salem, the railroad crosses the North River on a single-track bridge approximately 35 feet long. The ties are directly affixed to wooden beams supported by stone abutments on the banks of the river and two wooden piers in the river bed. However, water marks on the bridge indicate that the water has almost reached the ties on occasion. Bridge east of Flint Street



6. **Waters River Bridge** - The Danvers Branch crosses the Water's River which constitutes the border between Peabody and Danvers approximately 1.4 miles north of Peabody Square. It is understood that Waters River Bridge was constructed 1945. Damaged by fire in 1983, the 150' structure has been out of service ever since.



7. **Cranes River Bridge** - The Danvers Branch also crosses the narrower Cranes River as it approaches Danversport. This 45' bridge consists of steel beams supporting wooden ties. The beams are supported by stone abutments and single wooden center pier. This bridge has been out of service since the Water's River bridge burned in 1983.



2.4.4 Crossings

All of the highway grade crossings on the study area railway lines are protected with simple “cross buck” warning signs. All of the crossings affected by any restoration of railway traffic would require the installation of automatic crossing warning systems with gates, bells and flashing lights, which typically total approximately \$400,000 each. Four quadrant gates or roadway median dividers would be necessary to provide a quiet zone where trains would be exempt from sounding their horns four times when they approach each crossing.

The railway crosses five streets at grade over two miles between Peabody Square and Salem Station. There are two pedestrian crossings just west of the Salem Commuter Rail Station. The photographs below document the condition of these crossings.

1. Wallis Street – Peabody
2. Caller Street – Peabody
3. Howley Street – Peabody
4. Grove Street – Salem
5. Flint Street – Salem

Headed west from Peabody Square, toward First Avenue, the railway crosses nine additional roadways over 2.6 miles in Peabody:

1. Central Street
2. Lowell Street
3. Church Street
4. Franklin Street
5. Rousselot Private Crossing
6. Allens Lane
7. Summit Street
8. Corwin Street
9. First Avenue

Headed north from Peabody Square toward Danvers the railway crosses four roadways in approximately three miles:

1. Central Street – Peabody (also crossed enroute to Rousselot)
2. Purchase Street – Danvers
3. Park and Ash Streets – Danvers
4. Elm Street – Danvers

Any crossings that would host passenger traffic would need significant upgrades to the track structure and the provision of automatic highway warning devices (gates, flashers and bells) to reduce the risk of collisions between the rail vehicle and roadway users.

2.5 Funding Support

This section describes how other agencies have paid for new transit projects. A very broad range of funding sources are used to pay for the capital and operations and maintenance (O&M) costs of projects across the country. In Massachusetts, the range is narrower. This section describes funding tools and sources that might work for the Peabody Trolley.

2.5.1 Local Funding

Under Massachusetts law, the City of Peabody is obliged to provide support for the operation of the Massachusetts Bay Transportation Authority. Like all of the 175 cities and towns in the MBTA district, Peabody's annual assessment is calculated using a complex formula that uses population and other factors to derive an annual contribution. In FY2019, Peabody's contribution totaled \$1.16 million.

In Massachusetts, like most other states, local contributions to transit funding is primarily provided through General Fund allocations and dedicated local option taxes and fees. Value capture mechanisms can also provide funding for transit investments. The application of dedicated local taxes and value capture mechanisms (defined below) for transit is circumscribed by each state's enabling legislation that allows or restricts the use of these funding sources for transit. Below is a list and description of common local funding options.

- **Sales taxes** are the most widely used source of dedicated transit funding. Sales tax rates typically range from 0.25 to 1.0 percent dedicated to transit, applied to purchased goods or services. Given the broad tax base of dedicated sales taxes, revenues can usually be applied to both capital and

operating expenses, and some agencies pledge sales tax revenues to support debt financing of major capital investments. Many bus rapid transit (BRT) and light rail transit (LRT) systems in the U.S. are funded through dedicated sales tax revenues.

To the best of the team's knowledge, there are no local sales taxes in Massachusetts.

- **Property taxes** are generally the principal source of revenue for local governments (with revenues going into the General Fund), but some states provide enabling legislation that allows property tax revenues to be dedicated to transit.

For the first time in recent memory, local property tax revenues from several municipalities that would benefit from new service was pledged to help defray a small fraction of the cost of the MBTA Green Line extension in Cambridge, Somerville and Medford.

- **Motor fuel taxes** are generally levied as an excise tax (i.e., cents per gallon), although some local governments apply a sales tax on the price of fuel, with levies dedicated to transportation. Motor fuel tax revenues, however, are not a common funding source for transit at the local level, although they have been authorized and used by some transit agencies.

Massachusetts' motor fuel tax of \$0.2654 per gallon is 25th among US state rates ranging between 12 cents and 58 cents per gallon⁶. Gas tax revenues are used to pay transportation-related expenses, including debt service on bonds issued for all transportation purposes. The tax revenues also finance highway maintenance and safety services and the state's share of federally sponsored highway projects as required.⁷ In 2016, Massachusetts gas tax revenue totaled \$766 million.⁸

- **Vehicle fees** include registration fees, driver license fees and car rental taxes. They are not in widespread use for transit. There are no significant local vehicle fees in Massachusetts.
- **Employer/payroll taxes** refer to taxes imposed directly on employers for the amount of gross payroll paid for services performed within a transit district. Income taxes are applied to individual earnings, but are less commonly applied at the local level. There are no local payroll taxes in Massachusetts.
- **Utility taxes/fees** are local utility charges to property for access to the transportation system, mainly used for local roads and streets. Transportation utility rates can be set using different measures, including fees that apply per unit of housing or parking space, fees based on square footage or gross floor area, and fees that vary with the trip generation rate of a given property type.
- **Room/occupancy taxes** are applied either as a sales tax on the cost per room or as a daily fee per room, and are dedicated typically to tourism or tourism-related facilities. They may be implemented to support transportation investments where these are needed to enhance the visitor experience, mobility and accessibility.

⁶ https://en.wikipedia.org/wiki/Fuel_taxes_in_the_United_States

⁷ <https://blog.mass.gov/transportation/uncategorized/current-gas-tax-where-does-it-go/>

⁸ https://www.masslive.com/politics/index.ssf/2016/07/massachusetts_motor_fuels_tax.html

- **General revenues** (non-dedicated) refer to funding provided by local governments for transit services, whether it is through a jurisdiction's annual budget and appropriations process, through grants/contributions, or through negotiations or local agreements between the transit service provider and the jurisdiction(s) within the transit service area.
- **Value capture mechanisms** are special types of "property taxes" or fees that are targeted to capture the benefits or cost of infrastructure that serves property development. To date, this source has not been utilized on most projects, and when used typically contributes less than five percent of total project costs. Some of the most common value capture techniques are described below.
- **Impact fees** are one-time charges to developers on new development. Revenues are typically used to pay infrastructure improvements that are required to meet the increase in demand generated by the new development. In Massachusetts, traffic impact fees are sometimes charged for large developments that affect the local traffic network. It's not clear how a Peabody Trolley would be financed with such a revenue source⁹.
- **Tax Increment Financing (TIF)** districts are created to capture the increase in property tax levies over the base or expected future levies as a result of infrastructure improvements. The additional levies are typically pledged to bonds issued to finance infrastructure improvements.
- **Special assessment districts** are created to levy additional property taxes dedicated to infrastructure improvements serving the district, with the approval of property owners.
- **Joint development** involves a partnership between the transit agency and a private developer, commonly applied to transit-oriented development (TOD) on land at or adjacent to transit stations.

In all cases, both nationally and in the Northeast, state sources of funding have been an integral part of each project's financial plan, including both construction and ongoing operations.

i. Peabody Foundation

George Peabody, who was born in what was then "South Danvers" and for whom the City of Peabody was later named, was a successful entrepreneur and philanthropist who established the Peabody Donation Fund in London with an initial gift of £150,000. Today the Trust remains largely focused on its initial mission of providing housing for poor and working class residents of London. The value of the Trust has grown to £6,112,943¹⁰ - \$7.8 billion. The Trust's mission calls for helping "people make the most of their lives by providing good quality homes, working with communities and promoting wellbeing." In the spirit of community development, the Peabody Group might consider helping its founder's birthplace with a donation to seed an important public transportation and community development program.

⁹ <https://www.massbar.org/publications/massachusetts-law-review/massachusetts-law-review-article/massachusetts-law-review-2004-v88-n3/municipal-impact-fees-in-massachusetts>

¹⁰ (\$7,816,063)

2.5.2 State Funding

State funds are the most prevalent source of non-federal revenue to support the development and operation of public transport systems in the Commonwealth. Most state transportation dollars in Massachusetts are automatically dedicated to transportation from designated revenue sources such as the tax on gasoline, car sales, registry fees, tolls, or a portion of the sales tax.

These revenues are generally funneled through two big transportation funds that serve as conduits to collect transportation revenues and direct the funds for operations at particular agencies or to pay off debt for past spending.

1. The Commonwealth Transportation Fund (CTF) is an instrument of the state budget that receives annual funds from particular revenue sources, as designated by law.
2. The Massachusetts Transportation Trust Fund (MTTF) sits outside the Commonwealth budget as a financial instrument for the Department of Transportation. It is the repository for dedicated revenues from quasi-independent toll agencies, federal government grants, and some budgeted money from the state.

Both the CTF and the MTF were created in by the 2009 Transportation Reform Law that consolidated many agencies under the Massachusetts Department of Transportation.

Figure 5.1 shows the flow of state transport funding through the Commonwealth. It doesn't show federal funds, which help support capital projects and vary annually based on the timing of federal grants and reimbursements.

The biggest transport spending agencies are the MBTA (\$1,509 million per year) and MassDOT (\$853 million). Annual state expenditures for public transportation include \$1,509 million for MBTA services and \$80 million for the Regional Transportation Authorities that provide public transport outside the 175 cities and towns in the MBTA district. In addition to operating expenses, the MBTA spends \$413 million on debt service. The MBTA's largest sources of revenue are listed below.

Revenue Source	Annual Revenue (2017–millions)	% of Total
Statewide Sales Tax	\$971	51%
Passenger Revenues	\$603	32%
Local Assessments from Cities and Towns	\$160	8%
Additional State Assistance	\$126	7%
Non Passenger Operating Revenues	\$43	2%
Total	\$1,903	100%

The City of Peabody's local government contribution to the MBTA operating budget was \$1.16 million in FY2019.

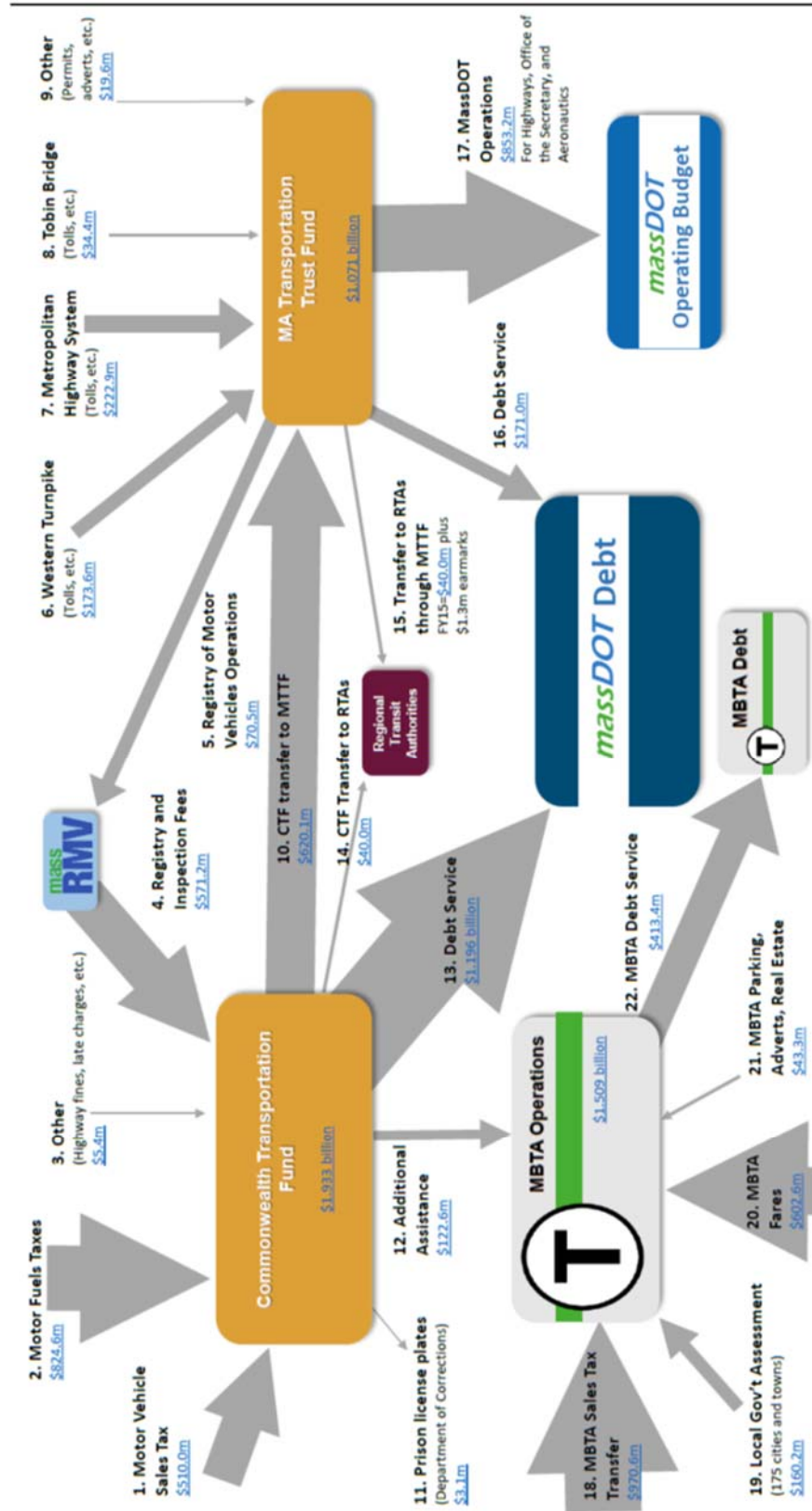


Figure 5: Transportation Funding in Massachusetts

Major sources for funding all state spending on transportation in the Commonwealth are itemized below with 2017 values¹¹.

- Motor Vehicle Sales Tax: \$510,030,805.
- Motor Fuel Taxes: \$824,640,027.
- Registry and Inspection Fees: \$571,159,664.
- Western Turnpike tolls and other revenue: \$173,563,000.
- Metropolitan Highway System tolls and other revenue: \$222,876,000.
- Tobin Bridge tolls and other revenue: \$34,442,000.
- Sales tax transfer to MBTA: \$970,637,174¹².
- Local Government Assessments: \$160,159,000¹³.
- MBTA fares: \$602,626,507.
- MBTA parking, ads, real estate, etc.: \$43,341,534.

Across the nation, most transit funding provided by states comes from General Fund appropriations, or through traditional taxes and fees, such as motor fuel taxes, sales taxes, and vehicle fees. State funding for transit is generally for both providing operating assistance and capital funds, but only a few states provide dedicated funding either for capital expenses (Arkansas, Idaho, Kentucky and Nevada) or operating expenses (Maine, South Dakota and Wisconsin).

As reviewed above, Peabody should expect that the Commonwealth and/or the MBTA would be the principal source of non-federal funding for development and operations of any Peabody passenger rail service. The MBTA would be the grantee and conduit for any federal funding.

2.5.3 Federal Funding Sources

Within the U.S. Department of Transportation, the Federal Transit Administration (FTA) administers the primary funding programs available for public transportation investments. The Federal Highway Administration (FHWA) administers some federal-aid highway programs with flexible provisions that allow the transfer of funds for public transportation investments. The Federal Railroad Administration (FRA) administers the Railroad Rehabilitation & Improvement Financing (RRIF) program, which can be used for passenger rail projects.

In addition, federal finance tools are available that can be used to advance project implementation by leveraging future revenue streams of dedicated funding. These will be discussed later on.

This section summarizes potential federal funding and the Peabody Trolley project's eligibility to apply for them. Examples of other projects that have used these sources as part of their funding plan are

¹¹ http://massbudget.org/report_window.php?loc=What-Does-MA-Transportation-Funding-Support.html

¹² Nominally a 1% sales tax (not including meals) on all purchases in Commonwealth. The amount dedicated to the MBTA is subject to an inflation-adjusted floor, plus \$160 million annually. Effective for fiscal 2015, the \$160 million adjustment was integrated into the inflation-adjusted floor, which was reset at \$970.6 million, and the amount of sales tax statutorily credited to the MBTA was increased by \$160 million. The floor grows by the allowable base revenue growth (lesser of sales tax growth or inflation, but not greater than 3% and not less than 0%) thereafter.

¹³ Assessed to 175 member communities associated with the transit authority. For a description of the assessment and the formula for cities and towns, see "Cherry Sheet Manual," Division of Local Services, p. 37
<http://www.mass.gov/dor/docs/dls/cherry/cherrysheetmanual.pdf>

identified. Table 5 provides a high-level summary of the federal funding sources and tools discussed in this section, including potential eligibility.

Table 5: Federal Funding Sources and Tools Potentially Available for Peabody Trolley Service Development				
Funding Source	Capital, Operations, Both	Eligible Mode	Formula/ Competitive	Comments
FTA 5309 Capital Investment Grant (New and Small Starts) Program	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Competitive	For New Starts projects, CIG share capped at roughly 50 percent of capital costs; for Small Starts, cap is \$75 million
FTA 5307 Urbanized Area Formula Grants	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Formula amounts, which are calculated based on metrics that included fixed guideway route and revenue vehicle miles, would increase following implementation of one of the commuter rail alternatives
FTA 5337 State of Good Repair (SGR) Grants	Capital	Light Rail Commuter Rail	Formula	After seven years of rail implementation
FHWA National Highway Performance Program	Capital	TBD	Formula	Must benefit the National Highway System
FHWA Surface Transportation Program (STP)	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Flex
FHWA Congestion Mitigation and Air Quality Improvement Program (CMAQ)	Both	Fixed Guideway Bus, Light Rail, Commuter Rail	Formula	Flex
U.S. DOT Transportation Investment Generating Economic Recovery (TIGER)	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Competitive	Suspended and replaced by BUILD Described below.
U.S. DOT	Capital	Fixed Guideway	Competitive	Very competitive capital program that replaced TIGER.

Better Utilizing Investments to Leverage Development (BUILD)		Bus, Light Rail, Commuter Rail		Maximum award is \$25 M
U.S. DOT Transportation Infrastructure Finance and Innovation Act (TIFIA)	Capital	Fixed Guideway Bus, Light Rail, Commuter Rail	Competitive	Loan Program
FRA Railroad Rehabilitation & Improvement Financing (RRIF)	Capital	Commuter Rail	Competitive	Loan Program

i. Flexible Funds: FHWA and FTA Programs

Flexible funds are certain legislatively specified funds that may be used either for transit or highway purposes. The decision to transfer funds between these federal programs, or to utilize the broad eligibility allowed in some federal funding programs, is made by state and local decision makers, in consultation with federal officials, and in the context of the metropolitan planning process.

The flexible funding provision was first included in the Intermodal Surface Transportation Efficiency Act of 1999 (ISTEA) and was continued with the Transportation Equity Act for the 21st Century (TEA-21) and the 2015 Fixing America's Surface Transportation (FAST) Act. The idea of flexible funds is that a local area can choose to use certain federal surface transportation funds based on local planning priorities, not on a restrictive definition of program eligibility. Flexible funds include FHWA Surface Transportation Block Grants (STBG) funds and Congestion Mitigation and Air Quality Improvement Program (CMAQ) and FTA Urban Formula Funds.

When FHWA funds are transferred to the FTA they are transferred to one of the following three federal programs:

- Urbanized Area Formula Program (5307)
- Nonurbanized Area Formula Program (Section 5311 program)
- Elderly and Persons with Disabilities Program (Section 5310 program).

Upon transfer to the FTA for a transit project, the funds are administered as FTA funds and take on all the requirements of the FTA program. Transferred funds may use the same non-federal matching share that the funds would have if they were used for highway purposes and administered by FHWA.

In urbanized areas over 200,000 in population, such as the Boston Metropolitan Region, the decision on the transfer of flexible funds is made by the Metropolitan Planning Organization (MPO). The MPO for the Boston region is the Central Transportation Planning Staff (CTPS). In areas under 200,000 in population the decision is made by the MPO in cooperation with the State DOT. In rural areas, the transfer decision is made by the State DOT. The decision to transfer funds is designed to be established for an area and flow from the transportation planning process.

ii. FTA Capital Investment Grant Program (Section 5309) – New and Small Starts

The FTA Section 5309 Capital Investment Grant program is the primary federal funding source for major transit capital investments. Eligible projects include new fixed-guideways or extensions to fixed guideways, bus rapid transit projects, and projects that improve capacity on an existing fixed-guideway system. This discretionary program requires project sponsors to undergo a multi-step, multi-year process to be eligible for funding.

To be considered a Small Starts project, the total project cost in year of expenditures dollars must be under \$250 million, and the Small Starts share must be less than \$75 million. The program is chronically oversubscribed and thus extremely competitive. As a result, whether a Small or New Start, a project must demonstrate that it performs well according to FTA's project evaluation measures¹⁴ and that it has strong local commitment – i.e., sufficient state and local non-federal matching funds – to earn a portion of this limited federal capital funding source.

An attractive Peabody Trolley project would a logical candidate for a 5309 Small Starts Grant.

iii. FTA Urbanized Area Formula Grants (Section 5307)

The FTA Urbanized Area Formula Grant program provides grants for public transportation capital, planning, job access and reverse commute projects, as well as operating expenses in certain circumstances (rail fixed guideway projects are excluded from operating costs under this program). The funding formula is based on a combination of bus revenue vehicle miles, bus passenger miles, fixed guideway revenue vehicle miles, and fixed guideway route miles, as well as population, population density, and number of low-income individuals. The funding apportionment to Massachusetts for FY2018 totaled \$160 million.

Operation of the Peabody Trolley would expand the formula funding allocated to Massachusetts under the 5307 program by adding route miles, train miles and passenger miles to the state's rail transit network.

iv. FTA State of Good Repair Grants (Section 5337)

The State of Good Repair (SGR) program provides funding for capital projects to maintain, repair, and upgrade rail transit systems and high-intensity motor bus systems. It is a formula program, with grants allocated based in part on revenue vehicle miles and route miles. The program requires a 20 percent local match. Eligible recipients are state and local government authorities in urbanized areas with fixed guideway public transportation facilities operating for at least seven years.

Currently, the City of Peabody is not an eligible recipient. But funding under this program would become available to the owner and operator of the Trolley service seven years after the start of revenue service. The funds can be used for preventative maintenance and SGR activities.

¹⁴ FTA evaluates project justification in terms of several criteria: mobility improvements, cost effectiveness, transit supportive land use, economic impacts, and environmental benefits. Congestion relief is an additional measure of project justification although FTA has not yet determined a measurement approach for this criterion.

v. FHWA Surface Transportation Block Grant Program

The Surface Transportation Block Grant Program (STBG) provides the most flexibility in the use of funds. These funds may be used (as capital funding) for public transportation capital improvements, car and vanpool projects, fringe and corridor parking facilities, bicycle and pedestrian facilities, and intercity or intracity bus terminals and bus facilities. STBG funds can also be used for surface transportation planning activities, wetland mitigation, transit research and development, and environmental analysis. Other eligible projects under STBG include transit safety improvements and most transportation control measures.

STBG funds are distributed among various population and programmatic categories within a state. Some program funds are made available to metropolitan planning areas containing urbanized areas over 200,000 in population; STBG funds are also set aside to areas under 200,000 or under 50,000 in population. The largest portion of STBG funds may be used anywhere within the state to which they are apportioned.

vi. FHWA Congestion Mitigation and Air Quality Improvement Program

The FHWA CMAQ program funds transit system capital expansion and improvements that are projected to realize an increase in ridership, travel demand management strategies and shared ride services, and pedestrian and bicycle facilities. Projects must have a transportation focus, reduce air emissions, and be located in or benefit an air quality nonattainment or maintenance area. Funding is distributed based on a formula that considers the severity of air quality problems. The federal share is 80 percent for most CMAQ projects.

In FY 2018, Massachusetts received \$65.5 million in CMAQ funds. Under current rules, CMAQ funds can be used for the project's capital expenses as well as operating costs for a limited period of time. Operating assistance is limited to certain activities, including new transit, commuter and intercity passenger rail services. Under MAP-21, the operating funding period was extended from three to five years.

vii. Better Utilizing Investments to Leverage Development (BUILD) Transportation Discretionary Grants

The successor to the U.S. DOT's TIGER program (Transportation Investment Generating Economic Recovery) is the BUILD program. BUILD Transportation Grants support surface transportation investments and are awarded on a competitive basis to projects that will have a significant local or regional impact. Evaluation criteria include safety, economic competitiveness, quality of life, environmental protection, state of good repair, innovation, partnership, and additional non-federal revenue for future transportation infrastructure investments.

There is \$1.5 billion available for BUILD Transportation Discretionary grants through September 30, 2020. The maximum grant award is \$25 million, and no more than \$150 million can be awarded to a single state. At least 30 percent of funds must be awarded to projects located in rural areas.

Less than 4% of the 2017 awards went to transit projects, a departure from previous TIGER rounds, which typically included 15-30% transit projects.

An attractive Peabody Trolley project would be a logical candidate for a BUILD Grant.

viii. Earmarks

Earmarks are funds provided by the Congress for projects or programs where the Congressional direction (in bill or report language) circumvents the merit-based or competitive allocation process, or specifies the location or recipient of federal financial assistance for a project. Congress includes earmarks in appropriation bills - the annual spending bills that Congress enacts to allocate discretionary spending - and also in authorization bills.

2.5.4 Federal Financing Tools

In addition to federal funding sources, there are federal finance tools available that can be used to advance project implementation by leveraging future revenue streams of dedicated funding. This section describes these tools.

i. U.S. DOT TIFIA Credit Assistance

The Transportation Infrastructure Finance and Innovation Act (TIFIA) program is a credit assistance program administered by the U.S. DOT providing direct loans, loan guarantees, and standby lines of credit. Surface transportation projects that cost \$50 million or more are eligible, including those for state and local governments, transit agencies, railroad companies, special authorities, special districts, and private entities. Any transit project eligible for grant assistance under the transit title of the U.S. Code (chapter 53 of 49 U.S.C.) and intercity bus vehicles and facilities are eligible for TIFIA credit assistance. In addition, rail projects involving the design and construction of intercity passenger rail facilities or the procurement of intercity passenger rail vehicles are also eligible. The TIFIA loan or loan guarantee amount should not exceed 49 percent of eligible costs; for standby lines of credit, the limit is 33 percent of the project costs. Dedicated revenues for repayment are required. Tax revenues, including sales taxes, are a common revenue pledge for TIFIA. The FAST Act authorized \$275 million in FY 2016 funds, \$275 million in FY 2017 funds, \$285 million in FY 2018 funds, \$300 million in FY 2019 funds, and \$300 million in FY 2020 funds in TIFIA budget authority from the Highway Trust Fund to pay the subsidy cost of TIFIA credit assistance.

The FAST Act expanded eligibility to include projects to improve or construct public infrastructure that are located within walking distance of, and accessible to Transit-Oriented Development Projects or TOD Projects. Eligible elements could include: property acquisition; demolition of existing structures; site preparation; utilities; building foundations; walkways; pedestrian and bicycle access to a public transportation facility; construction, renovation, and improvement of intercity bus and intercity rail stations and terminals; renovation and improvement of historic transportation facilities; open space; safety and security equipment and facilities; facilities that incorporate community services such as daycare or health care; a capital project for, and improving, equipment or a facility for an intermodal transfer facility or transportation mall; and construction of space for commercial uses.

ii. FRA Railroad Rehabilitation and Improvement Financing Program

The Railroad Rehabilitation and Improvement Financing Program (RRIF) is an FRA loan program enacted under TEA-21 that provides direct federal loans and loan guarantees to finance the development of

railroad infrastructure. Eligible applicants are railroads, state and local governments, government-sponsored authorities and corporations, joint ventures that include at least one railroad and limited option freight shippers who intend to construct a new rail connection. Loans can cover up to 100 percent of project costs with interest rates equal to U.S. Treasury rates. SAFETEA-LU made amendments to the program; the program website indicates that the FAST Act has made significant changes but is still in the process of implementing them. The Massachusetts Bay Transportation Authority (MBTA) is using both TIFIA and RRIF loans to install Positive Train Control on its commuter rail system.

2.5.5 Fares

The operating and maintenance costs of each alternative will be offset by the fares collected from riders. The typical fare revenue per passenger mile for a light rail trip in Greater Boston is \$0.48. The typical revenue per passenger mile for a commuter rail trip in Greater Boston is \$0.28.

Within the MBTA commuter rail fare regime, Peabody at 18.8 miles from North Station would be a Zone 4 trip (the same as Beverly) with a one-way adult fare of \$8.25 and an unlimited monthly pass price of \$263.00. The monthly pass includes free service on MBTA rapid transit and local bus services.¹⁵

Salem is a Zone 3 station with a one-way fare of \$7.50 and a monthly pass price of \$244.25. Commuter rail travel to Boston from Salem is approximately \$1 to \$1.50 less expensive for each travel day but this cost savings is more than offset by the Salem parking charges of \$5 per day.

¹⁵ The monthly pass price is roughly equivalent to 32 one way fares.

3 Opportunities and Constraints

Based on the goals and objectives and the existing conditions, the study team developed a brief narrative describing both the opportunities to provide a rail shuttle service and the constraints that limit the ability to operate such a service.

This analysis maps the aspirations of the goals and objectives onto the realities of existing conditions to develop an understanding of how existing and future conditions can support or block the proposed service.

3.1 Goals and Objectives

The service goals of local public officials comprise five elements.

1. Provide car-free transportation options for current and future residents of Peabody
2. Leverage existing rail infrastructure and services
3. Promote Peabody as a location for economic and residential investment
4. Provide car-free reverse commute opportunities for people working in Peabody but living in other communities
5. Promote connections between Peabody and neighboring communities

The analysis of opportunities and constraints considers the technological, institutional and economic opportunities and constraints that affect the feasibility of operating a rail shuttle “trolley” service linking Peabody with the MBTA commuter railroad network via Salem Depot.

3.2 Technological Opportunities

- The rail line is in place and maintained for 10 mph freight operations for 2.9 miles between Salem and Rousselot Manufacturing.
- Historic passenger rail service between Salem and Peabody was scheduled for 7 minutes of running time.
- Historic passenger rail service between Peabody and Danvers was scheduled for 10 minutes.
- With modern equipment the service could be faster than the historic running times.
- Current use of line is limited to two freight round trips per week¹. This provides capacity for a passenger service.
- The track configuration at Salem Depot would provide for a convenient transfer to and from the commuter rail service at Salem without interfering with commuter rail train movements.
- The number of conflicts between a Peabody and other activities in the corridor is limited (e.g. the number of highway grade crossings is manageable and the number of sensitive receptors near the railway are limited).
- With passenger service limited to 14 hours per weekday. There are clearly opportunities to avoid any conflicts with freight service.
- Service to and from Boston’s North Station at Salem Depot is very dense with 60+ trains each weekday. This creates many opportunities for coordinated transfers to and from Boston.

¹ State funding has been provided to Rousselot that will allow their plant to hold more cars onsite and reduce the number of weekly freight trains to one.

3.3 Technological Constraints

- The rail line is single track, limiting opportunities for bi-directional traffic and reducing overall carrying capacity of the line.
- The grade crossings will require upgrades to support higher speed and higher frequency operations
 - Five grade crossing between Salem Depot and Peabody Square
 - Four grade crossings between Peabody Square and Danvers
 - Nine grade crossings between Peabody Square and First Avenue in West Peabody.
- The railway crosses numerous bridges over waterways
 - Four bridges between Salem Depot and Peabody Square
 - Two bridges between Peabody Square and Danvers
 - One bridge between Peabody Square and First Avenue in West Peabody.

All of the bridges that are crossed by the shuttle will require upgrades or replacement.
- Local officials wish to avoid the noise, vibrations, and fumes associated with the operation of heavy diesel rail vehicles. Special safety provisions will be required to segregate any lighter self-propelled rail cars from the heavier conventional freight trains.
- The rail corridor between Salem and Peabody is subject to flooding when the Proctor Brook and North River swell with heavy rains. With sea level rise, the eastern portion of the rail route could be periodically inundated by high tides. Even now, storm surges affect the canal in Peabody Square.

3.4 Institutional Opportunities

- Potential access to the line for public use is enhanced due to its ownership by a governmental transportation agency.
- The owner of the line, the MBTA, is committed to the support of rail passenger transportation.
- The current MBTA portfolio of services offered in Peabody does not include attractive options for work travel to Boston without using a private automobile to drive to the nearest MBTA rail station. This creates an impetus for change.
- The political and social climate in Eastern Massachusetts is conducive to change and investment related to living inside the Route 128 Ring and in established urban communities like Peabody.
- A possible extension of the Trolley to Danvers would potential increase support for new service by expanding the markets it would serve.

3.5 Institutional Constraints

- Federal regulations require a waiver and special operating procedures to use a rail vehicle that does not comply with FRA standards on the rail line (e.g. electric light rail vehicle, lightweight self-powered rail car).
- The current use of the line for freight deliveries must be preserved.
- Available discretionary funds at the state and federal level for the development of new passenger services is very limited. Competition for funding is intense.

3.6 Economic Opportunities

- Together the MBTA and its contractor, Keolis Commuter Service, are a full-service passenger railway with access to the engineering, mechanical, transportation, and administrative resources necessary to design and operate a passenger service on the Peabody Branch.
- The passenger rail service would create meaningful options for transit oriented development in Peabody Square, enhancing economic opportunities and quality of life for residents of Peabody.
- Extending the passenger rail service to Danvers could expand the options for transit oriented development to a neighboring community.
- Public ownership of the line reduces cost of access for public transportation uses.
- Resources of non-governmental entities may be available to leverage funding for the service (e.g. Peabody Foundation).
- The MBTA charges \$5/day to park in the garage at the Salem station. The trolley would save passengers \$25/week in parking expenses.
- The trolley would need to charge a nominal fare to prevent loitering or vandalism. The fare could be coordinated with the Salem Commuter Rail fare: Peabody Square could be a Zone 4 pass to include the trolley. An adult round trip Salem Zone 3 ticket costs \$15.00. A round trip Zone 4 ticket from Peabody would add \$1.50 to that round trip fare.

3.7 Economic Constraints

- Fiscal resources of local governments to directly develop and support the service are negligible.
- The backlog of proposed rail transit initiatives including many State of Good Repair Projects for the MBTA and Greater Boston is substantial.
- The debt load of the MBTA from previous transportation infrastructure investments is very high with more than \$400 million in annual debt service payments.
- Parking at the trolley in Peabody Square would be limited, so the trolley would only serve passengers who walk, bike, or take a bus to it.

4 Service Alternatives

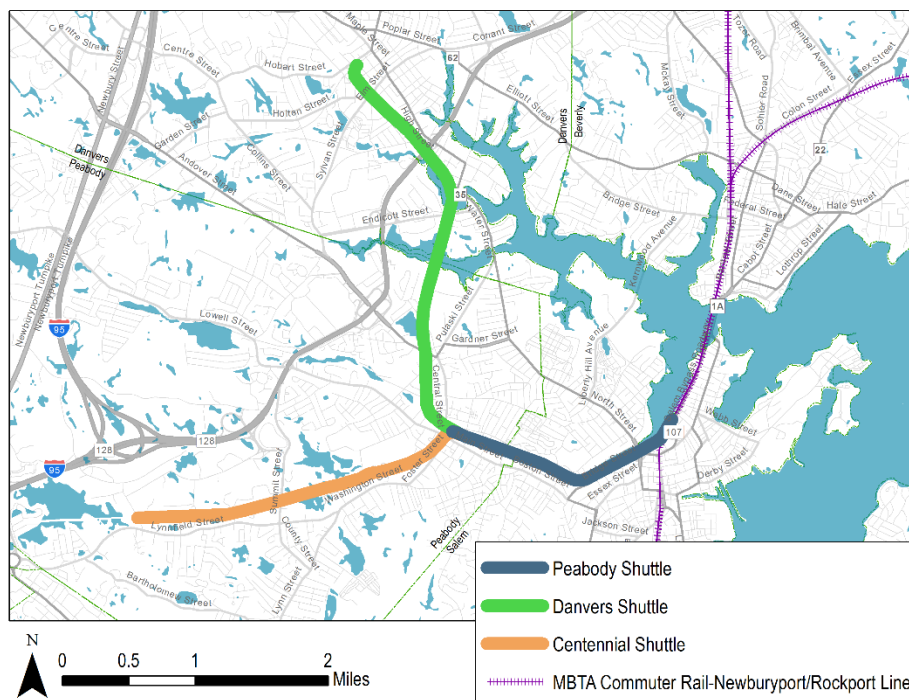
Two classes of service alternatives were considered and prepared. One class includes three rail alternatives (Peabody, Danvers, or Centennial) using the rail line between Peabody and Salem to provide connections for mainline commuter rail trains to and from Boston. The other class includes two bus options (Main Street Route or Walnut Street Route) using existing roadways to provide bus service between Peabody Square and Salem Depot for the purpose of connecting to other MBTA services, especially the commuter rail service to North Station, but also for connections to the other bus services that call on the bus lanes adjacent to the train station. This chapter describes each alternative and suggests potential service operators.

4.1 Rail Alternatives

As described in the existing conditions chapter, Peabody Square is connected to the MBTA's Salem Station by an active 2-mile segment of single track railway. The active railway continues west on the alignment of the former South Reading Railroad (1850-1925) for approximately 2 miles. In Peabody Square, the railway also connects to an intact, but inactive, rail right of way leading to Danvers via the former Danvers Branch of the Essex Railroad (1850-1983).

Passenger service on the South Reading Railroad ceased in 1925. Passenger service on the Danvers Branch ended in 1958. The study team developed and evaluated three rail service alternatives for connections to the MBTA's main line service between Salem Depot and North Station. In the interest of economy, each of the rail service alternatives were designed for a one-car train operating on a single track. Freight service would be scheduled to run overnight after the end of Peabody passenger service or in a slack midday window between passenger trains. The three rail alternatives are introduced below.

Figure 1



4.1.1 Peabody Shuttle

- 2 miles, 4 minutes, connecting with 36 MBTA trains to or from North Station daily
- Two stations were assumed: a transfer station at Salem Depot and a Peabody Square station between Central Street and Wallis street in Peabody. There are no intermediate stops between Peabody and Salem.
- The track and right of way investment required for the Peabody rail shuttle would be lower than for the longer shuttles. However, given the nature of making connections to a relatively infrequent number of commuter rail trains, the staffing and equipment requirements could be the same for a longer shuttle that serves additional travel markets.

4.1.2 Danvers Shuttle

- 5.1 miles, 10 minutes, connecting with 34¹ MBTA trains to or from North Station daily
- The Danvers shuttle was designed to run between the location of the former Danvers Station and a transfer station at Salem Depot, making intermediate stops at Danversport and Peabody Square. In the interest of efficiency, some peak trips were not scheduled to run all the way north to Danvers. Instead, they were terminated and turned at Peabody or Danversport so that they can return to make another connection at Salem Depot.
- The Danvers shuttle would require investing in three miles of new railroad and a new 150-foot rail bridge over the Waters River, but it would also allow the shuttle to serve downtown Danvers and provide a possible Danversport park-n-ride station at Exit 22 on I-95, where the interstate also connects with State Routes 62 and 35.

4.1.3 Centennial Shuttle

- 4.6 miles, 10 minutes, connecting with 34² MBTA trains to or from North Station daily
- The Centennial shuttle was designed to run between a terminal station at First Avenue and a transfer station at Salem Depot, making intermediate stops at Summit Street and Peabody Square. In the interest of efficiency, some peak trips were turned short of Summit Street to maximize service connections for Peabody Square travelers.
- Compared with the Danvers shuttle, the Centennial shuttle would save costs by upgrading existing track but is not well-oriented toward any significant population or employment centers.
- Pan Am owns the rail right of way between Peabody Square and Centennial Drive.

Station-to-station to running times for the three rail service alternatives were estimated for two levels of track improvement and three different types of rolling stock.

4.1.4 Maximum Allowable Speeds

Presently, the branch line linking Salem to Peabody is maintained to FRA Class 1 standards. Under the rules for Class 1 operations, all trains are restricted to a maximum speed of 10 mph. Two levels of Class 3 upgrade were considered:

¹ Due to the additional time needed to cover the increased distance to Danvers, this shuttle alternative would only be able to meet 34 trains instead of 36.

² Due to the additional time needed to complete the increased distance to Centennial Park, this shuttle alternative would only be able to meet 34 trains instead of 36.

- 45 mph maximum speed for passenger trains, 30 mph for freight
- 60 mph maximum speed for passenger trains, 45 mph for freight.

4.1.5 Rolling Stock Options

The team also considered three types of rail rolling stock.

- **Light Rail Vehicles (LRVs)** – A one-car 200-passenger electric train would draw traction power from an overhead wire. In

Boston, light rail is offered by the MBTA's Green Line and Mattapan services. Light rail trains in some locations share track with freight services. Most notably, the light rail systems in San Diego and Salt Lake City share track with local freight services that operate at night after the close of passenger service. The principal



Figure 2: MBTA Type 9 LRV on Test Track in Newton

advantages of LRV services are that the trains are quiet, nimble and light. Customer acceptance of LRV services is high. The MBTA's recent order of 24 Spanish 212-passenger LRVs came at price of \$7.29 million per car.

The principal disadvantages are that LRVs require an off board source of motive power distributed by a cable suspended above the track (aka catenary). The suspended cable and a supporting electric substation must be purchased, installed and maintained. The ride quality on the light cars is sometime rougher than on heavier cars designed to provide more passenger comfort.

Federal safety regulations require stringent safeguards when LRVs share track with conventional rail freight services. These safeguards are discussed in more detail elsewhere in this report.

- **Diesel Multiple Units (DMUs)** – A one-car 200-passenger diesel train would be powered by a ~750 HP engine. DMUs were used extensively during the 1950s and 60s in Boston for the provision of commuter service. With the rise of longer and less frequent commuter rail trains, the DMUs fell out of favor with commuter railroads.

But since the turn of the millennium, ten new North American DMU systems have opened. Most operate with less passenger density and shorter trips than traditional commuter railroads. Most operate on tracks with limited local freight service similar to the Pan Am freight deliveries in Peabody.



Figure 3: Swiss Designed Light DMU in Southern New Jersey

Most modern US DMU services use cars designed for the European market. Since these cars don't meet all the safety requirements specified for sharing track with freight trains, they are often operated like light rail services when sharing track with freight services and observe a strict diurnal temporal separation between passenger and freight trains: passengers during the daytime and evening, with freight operation overnight. Recent research and advocacy is slowly turning federal safety policy to recognize that international safety standards, while different from US rules, offer equivalent or better safety standards. Regulations to allow commingled freight and DMU operations are in the process of approval, but for the purposes of this study the status quo regulatory regime was assumed.

The principal advantages of a diesel propelled DMU are that it can approximate LRV service with generally a small improvement in ride quality while avoiding the cost of the electric catenary system. The eight Swiss 200-passenger cars recently delivered for a new service in the San Francisco Bay Area cost \$7.25 million each.

Due to a limited US market, the competition to deliver new DMUs for domestic consumption is limited. The safety regulations that stipulate how light rail cars share track with freight trains also apply to for foreign designed DMUs.

- **Diesel Push-Pull (PP)** represents the standard MBTA rolling stock for commuter rail operations. This rolling stock is fully approved for operation on tracks shared with freight operations. But compared with the light rail and DMU options, the much heavier push-pull trains cause more noise and vibration, offer slower acceleration, and use more fuel.



Figure 4: MBTA Diesel Push Pull Train

4.1.6 Rail Running Times

The calculations to forecast running time accounted for the stopping pattern, speed limits, acceleration curves, and braking requirements for each rolling stock type under each service regime. A 7% pad was added to all calculated figures to allow for human factors, including reaction times. Dwell times at intermediate stations were set at 30 seconds per station. The findings are summarized in Table 4.1 and graphed in Figure 4.2.

Table 4.1: Forecast Travel Time to Salem Transfer (hh:mm) by Rolling Stock and Maximum Allowable Speed

	LRV 45	LRV 60	DMU 45	DMU 60	PP 45	PP 60
Peabody Square	03:45	03:20	03:50	03:20	04:26	04:11
Danversport	07:47	06:53	07:56	06:52	09:09	08:35
Danvers	09:57	08:56	10:11	08:58	12:00	11:23
Summit Street	06:13	05:36	06:22	05:41	07:35	07:19
First Avenue	09:15	08:21	09:29	08:29	11:18	10:58

Inspection of Table 4.1 and Figure 4.2 shows that the Push-Pull rolling stock is considerably slower for the study services than the LRV or DMU rolling stock. This is primarily due to the slower acceleration of the heavier trains. By contrast, the running time between Salem and Peabody Square would be roughly equivalent using DMUs or LRVs. The slower travel times from the Push-Pull rolling stock argues in favor of using DMUs or LRVs.

DMUs and LRVs running at speeds of 45 to 60 mph would only save 30 seconds of travel time between Peabody and Salem. West of Peabody on either branch, higher speeds would save approximately another 30 seconds of running time. Since the overall time savings from higher speeds would be the range of only 30 to 60 seconds, the study recommends for the purposes of this planning study that we assume the lower 45 mph maximum speeds that may result in less community concern about fast trains, and will marginally lower infrastructure maintenance costs.

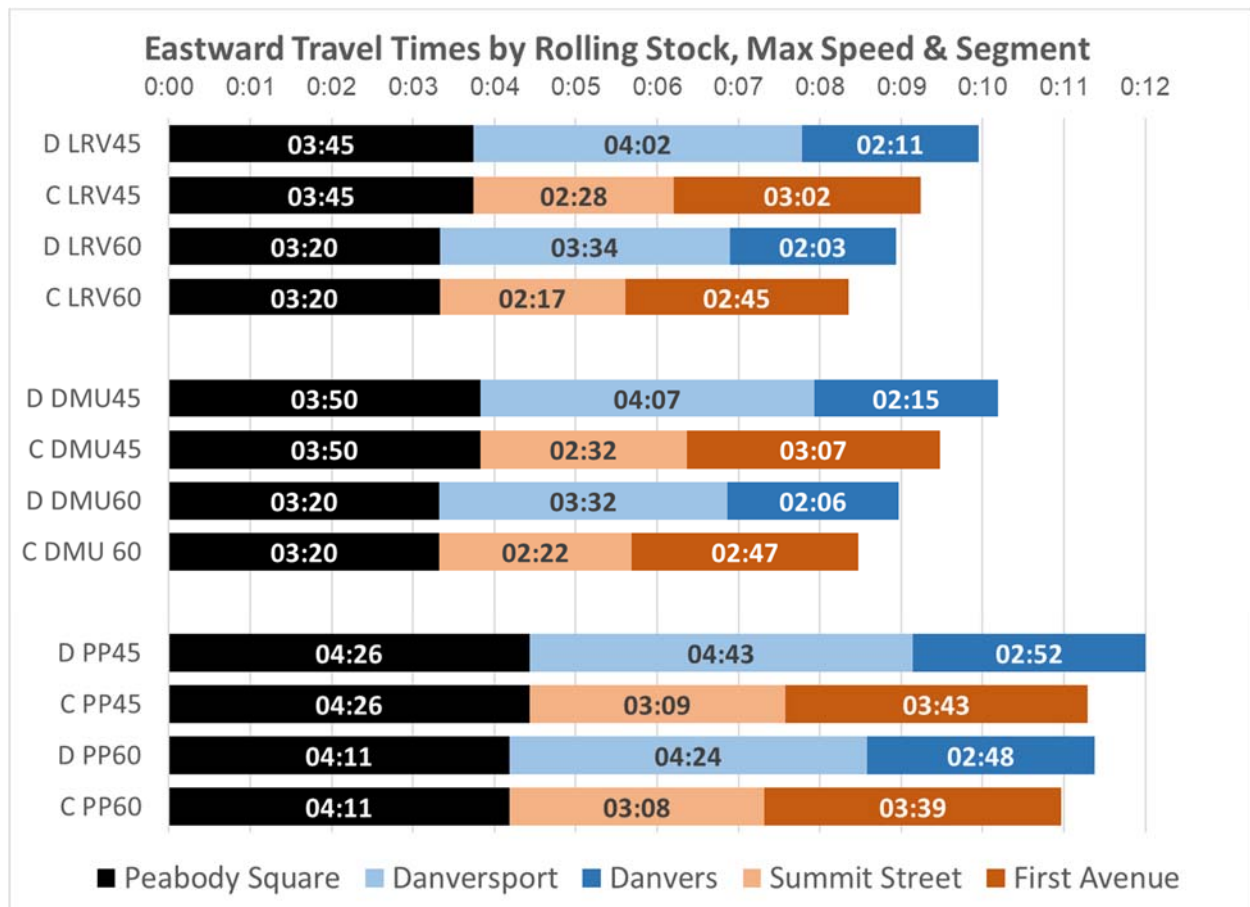


Figure 5

For the purposes of developing a conceptual schedule of weekday services for each option, the study team conservatively assumed that the service would be run with either DMUs or LRVs (the performance differences between the two types of equipment are negligible) with a maximum allowable passenger line speed of 45 mph. The scheduled running times employed to develop the conceptual timetables are shown in Table 4.2.

Table 4.2 Scheduled Travel Times to Salem Transfer Station		
Station	Miles to Boston	h:mm
First Avenue	21.4	0:10
Summit Street	20.3	0:08
Danvers	21.9	0:10
Danversport	21.0	0:08
Peabody Square	18.8	0:04
Salem Transfer	16.8	0:00

4.1.7 Rail Service Designs

The conceptual shuttle services were designed to connect at Salem Depot with trains bound for North Station and with trains returning from Boston. Where possible, each trip to service a Boston-bound train was also scheduled to service an outbound train on its return. In accordance with accepted practice elsewhere in the industry, five minutes was allowed for the transfer to Boston-bound trains. Three minutes was allowed for trains returning from Boston in what has been termed a “load-and-go” service design. Since the shuttle trains and shuttle trips were so short (one car and four to ten minutes) a minimum of five minutes’ recovery was allowed at each end of the line before a return trip was scheduled. (Longer trips (30 to 60 minutes) and longer trains (5 to 8 coaches) would generally require a minimum of ten minutes recovery time.)

The conceptual schedules were designed to coordinate with the existing MBTA Newburyport/Rockport weekday service in effect during August 2018. No weekend schedule concepts were prepared. If the mainline Newburyport/Rockport schedule of services were to change, as it does from time to time, the schedule of services for the shuttle would need to be adjusted.

Peabody Shuttle

The conceptual timetable for a two-mile, four-minute non-stop Peabody Shuttle is shown in Figure 6. (The full timetable is provided in Appendix B.) The simple Peabody Shuttle provides 36 connections to North Station trains: 18 inbound and 18 outbound. The average scheduled travel time between Peabody and North Station, including the 5-minute inbound transfer or the 3-minute outbound transfer, would be 40 minutes. The minimum travel time would 33 minutes when connecting to outbound express trains. The longest scheduled travel time would be 49 minutes.

Figure 6: Conceptual Peabody Square Rail Shuttle Schedule: Summary

Peabody Square - North Station Conceptual Weekday Shuttle Rail Schedule																				
INBOUND	152	154	104	156	106	160	108	110	112	168	116	170	118	172	120	174	122	176	124	126
Peabody	6:13	6:43	7:04	7:24	7:44	8:19	8:49	9:53	11:33	13:32	14:23	15:17	16:03	17:06	17:39	18:10	18:28	19:06	19:48	21:11
North Station	6:49	7:31	7:40	8:08	8:22	8:55	9:31	10:34	12:14	14:13	15:05	15:59	16:45	17:50	18:25	18:50	19:04	20:11	20:29	22:00
Travel Time	0:36	0:48	0:36	0:44	0:38	0:36	0:42	0:41	0:41	0:41	0:42	0:42	0:42	0:44	0:46	0:40	0:36	1:05	0:41	0:49
OUTBOUND	153	101	191	103	105	159	161	163	111	113	115	117	119	171	173	175	177	125		
North Station	6:26	6:39	7:08	7:50	8:35	9:40	11:20	13:20	13:50	15:35	16:15	17:00	17:30	17:40	18:05	18:45	19:35	20:45		
Peabody	6:59	7:16	7:57	8:33	9:14	10:19	11:59	13:59	14:36	16:16	16:56	17:33	18:03	18:23	18:44	19:26	20:14	21:26		
Travel Time	0:33	0:37	0:49	0:43	0:39	0:39	0:39	0:39	0:46	0:41	0:41	0:33	0:33	0:43	0:39	0:41	0:39	0:41		

Danvers Shuttle

The conceptual timetable for a five-mile, ten-minute two-stop Danvers Shuttle is shown in Figure 7. (The full timetable is provided in Appendix B.) The Danvers Shuttle provides 34 connections between Peabody and North Station: 17 inbound and 17 outbound. Thirty-one shuttles service Danversport and 29 shuttles service Danvers. The average scheduled travel time between Peabody and North Station, including the 5-minute inbound transfer or the 3-minute outbound transfer, would be 40 minutes. The minimum travel time would be 36 minutes. The longest scheduled travel time would be 49 minutes.

Figure 7: Conceptual Danvers Shuttle Schedule

Danvers - North Station Conceptual Weekday Shuttle Rail Schedule																	
INBOUND	152	104	106	160	108	110	112	168	116	170	118	172	120	174	122	124	126
Danvers	6:07	6:58	7:38	8:13	x	9:47	11:27	13:26	14:17	15:11	15:57	x	17:33	18:06	x	19:42	21:05
Peabody Square	6:13	7:04	7:44	8:19	8:49	9:53	11:33	13:32	14:23	15:17	16:03	17:06	17:39	18:12	18:28	19:48	21:11
Salem (dep for North Station)	6:22	7:13	7:53	8:28	8:58	10:02	11:42	13:41	14:32	15:26	16:12	17:15	17:51	18:24	18:29	19:57	21:27
North Station	6:49	7:40	8:22	8:55	9:31	10:34	12:14	14:13	15:05	15:59	16:45	17:50	18:25	18:50	19:04	20:29	22:00
Peabody Travel Time	0:36	0:36	0:38	0:36	0:42	0:41	0:41	0:41	0:42	0:42	0:42	0:44	0:46	0:38	0:36	0:41	0:49
OUTBOUND	101	191	103	105	159	161	163	111	113	115	193	169	171	173	175	177	125
North Station	6:39	7:08	7:50	8:35	9:40	11:20	13:20	13:50	15:35	16:15	16:40	17:15	17:40	18:05	18:45	19:35	20:45
Salem (dep for Danvers)	7:07	7:40	8:23	9:07	10:12	11:52	13:52	14:23	16:09	16:49	17:12	17:47	18:14	18:37	19:19	20:07	21:17
Peabody Square	7:16	7:57	8:33	9:14	10:19	11:59	13:59	14:36	16:16	16:56	17:19	17:54	18:23	18:44	19:26	20:14	21:26
Danvers	7:22	8:03	x	9:20	10:25	12:05	14:05	14:42	16:22	x	17:25	18:00	x	18:50	19:32	20:20	21:32
Peabody Travel Time	0:37	0:49	0:43	0:39	0:39	0:39	0:39	0:46	0:41	0:41	0:39	0:39	0:43	0:39	0:41	0:39	0:41

Centennial Shuttle

The conceptual timetable for a 4.6-mile, ten-minute two-stop Centennial Shuttle is shown in Figure 8. (The full timetable is provided in Appendix B.) Like the Danvers Shuttle, the Centennial Shuttle would 34 connections between Peabody and North Station: 17 inbound and 17 outbound. Thirty-one shuttles service the Summit Street Station and 29 shuttles service the proposed First Avenue Station. The average scheduled travel time between Peabody and North Station, including the 5-minute inbound transfer or the 3-minute outbound transfer, would be 40 minutes. The minimum travel time would be 36 minutes. The longest scheduled travel time would be 49 minutes.

Figure 8: Conceptual Centennial Shuttle Schedule

Centennial - North Station Conceptual Weekday Shuttle Rail Schedule																		
INBOUND	152	104	106	160	108	110	112	168	116	170	118	172	120	174	122	176	124	126
First Avenue	6:07	6:58	7:38	8:13	x	9:47	11:27	13:26	14:17	15:11	15:57	x	17:33	18:06	x	19:00	19:42	21:05
Peabody Square	6:13	7:04	7:44	8:19	8:49	9:53	11:33	13:32	14:23	15:17	16:03	17:06	17:39	18:12	18:28	19:06	19:48	21:11
North Station	6:49	7:40	8:22	8:55	9:31	10:34	12:14	14:13	15:05	15:59	16:45	17:50	18:25	18:50	19:04	20:11	20:29	22:00
Peabody Travel Time	0:36	0:36	0:38	0:36	0:42	0:41	0:41	0:41	0:42	0:42	0:42	0:44	0:46	0:38	0:36	0:00	0:41	0:49
OUTBOUND	101	191	103	105	159	161	163	111	113	115	193	169	171	173	175	177	125	
North Station	6:39	7:08	7:50	8:35	9:40	11:20	13:20	13:50	15:35	16:15	16:40	17:15	17:40	18:05	18:45	19:35	20:45	
Peabody Square	7:16	7:57	8:33	9:14	10:19	11:59	13:59	14:36	16:16	16:56	17:19	17:54	18:23	18:44	19:26	20:14	21:26	
First Avenue	7:22	8:03	x	9:20	10:25	12:05	14:05	14:42	16:22	x	17:25	18:00	x	18:50	19:32	20:20	21:32	
Peabody Travel Time	0:37	0:49	0:43	0:39	0:39	0:39	0:39	0:46	0:41	0:41	0:39	0:39	0:43	0:39	0:41	0:39	0:41	

Each of the shuttle services provide a new direct transit path between Boston and Peabody that cuts the current direct transit travel time by nearly one hour. Fairly fast transit services to Boston are available nearby but all require the use of private automobile to access Salem, Lynn or Wonderland stations on the commuter railroad or MBTA Blue Line.

Table 4.3 Rail Shuttle Service Summary

Shuttle Service	Peabody	Danvers	Centennial
Length (Miles)	2.0	5.1	4.6
Travel Time (Minutes)	4	10	10
Intermediate Stops	0	2	2
Weekday Peabody Connections to Boston	36	34	34
<i>Trip Durations b/w Peabody Square and North Station (Minutes)</i>			
Average	40	40	40
Minimum	33	36	36
Maximum	39	49	49

4.2 Bus Alternatives

As described in the existing conditions chapter, Peabody Square is served by three MBTA bus routes. A bus shuttle linking Peabody Square to Salem Depot would offer a fourth independent service that could be developed and operated in coordination with these routes.

Table 4.4 MBTA Bus Routes Serving Peabody Square

Route	Description	Weekday Trips	Weekday Riders ³	Peabody Square Passenger Trip Ends
434	Peabody to Boston via Lynn	2	20	5
435	Liberty Tree Mall to Lynn via Peabody Square	31	350	134
465	Liberty Tree Mall to Salem Depot	25	330	150

Similar to the Peabody Square rail shuttle described above, the bus shuttle would provide non-stop express service linking Peabody Square with Salem Depot. Whereas the rail shuttle would use the tracks shared with freight services, the bus shuttle would use local streets shared with general roadway traffic.

A bus depot could be developed in the publicly owned triangle formed by the wye connection between the Danvers and Centennial branch rail lines. The bus depot would be used by all MBTA bus routes serving Peabody Square. A one-way only eastbound roadway (linking Central Street with Wallis Street) would be developed parallel to the Danvers Branch with two bus berths south of the busway. Eastbound and southbound trips of the Peabody-Salem Shuttle, MBTA Route 434, MBTA Route 435 and MBTA Route 465 would all use the busway. When they reach Wallis Street, the existing routes would run south to Main Street and return to their current alignment. The Peabody-Salem Shuttle could follow the existing services out to Main Street or turn left for access to Walnut Street, which would provide a faster and more reliable non-stop express route to Salem.

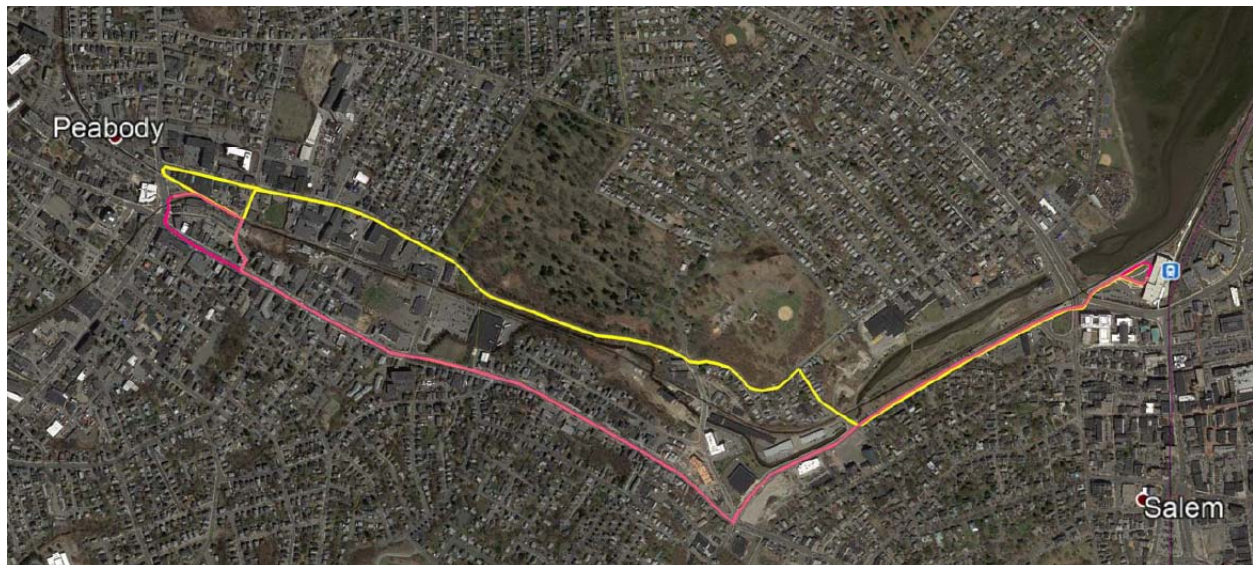
³ MBTA Planning and Scheduling Data from 2017.

The bus depot would provide an attractively landscaped landmark and activity center in Peabody Square. The T logo would be poised conspicuously on Central Street marking the center for public transport in downtown Peabody. The bus berths would have full length shelters, passenger information boards, and variable message signs showing the anticipated next arrival and departure times for each route.

The shuttle vehicle would be a 40-foot bus drawn from the fleet of 96 buses based at the MBTA's Lynn Garage. The newer buses are mostly diesel-electric hybrids with room for 40 seated and 16 standing passengers. If the shuttle proved especially attractive, a larger 60-foot bus could be assigned to the service. All the newer buses are low floor and ADA compliant.



Two routings for the Peabody-Salem bus shuttle were identified as shown in the map below.



4.2.1 Main Street Route (Red)

The eastbound bus would run east down the busway to Wallis Street, South on Wallis, East on Main Streets and Boston Streets to Bridge Street. East on Bridge Street to Salem Depot. See Red Line on map below.

Return trips would follow the same route westward but would bypass Wallis Street to run west to Central Street. North on Central to turn eastward into the bus depot.

This route would encounter seven or eight traffic signals and up to two stop signs depending on direction. Anticipated bus travel times derived from online sources show that scheduled running time for this route would range between eight and 16 minutes depending upon direction and time of day.

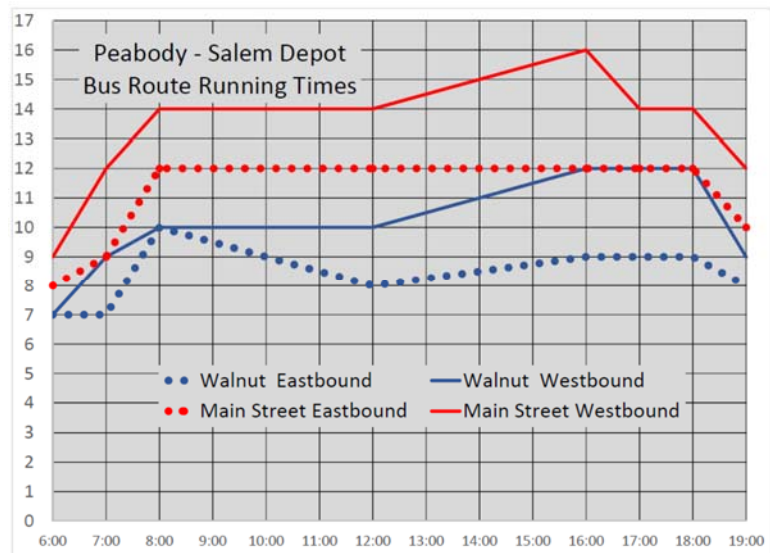
4.2.2 Walnut Street Route (Yellow)

The eastbound bus would run east down the busway to Wallis Street, north on Wallis, east on Walnut, Harmony Grove and Mason Streets to Flint Street. South on Flint to Bridge Street. East on Bridge Street to Salem Depot.

Return trips would follow the same route westward but would bypass Wallis Street to run west to Central Street. South on Central to turn eastward into the bus depot.

This route would encounter four or five traffic signals and up to three stop signs depending on direction. Anticipated bus travel times derived from online sources show that scheduled running time for this route would range between seven and 12 minutes depending upon direction and time of day.

The figure shows anticipated bus running times for the two route alternatives eastbound and westbound by time of day. In the eastbound direction the Walnut Street route is two to four minutes faster than the Main Street route during most times of the day. In the westbound direction, the Walnut Street route is generally four minutes faster than the Main Street route.



4.2.3 Bus Service Designs

The conceptual timetable for a two-mile, non-stop Peabody Square-Salem Depot Bus Shuttle is shown in Figure 6 and Table 4.3. Running times between Peabody Square and the Salem Depot following the Walnut Street route range between 7 and 12 minutes depending upon time of day and direction. The bus shuttle like the rail services was scheduled to provide a five-minute connection time to Boston-bound trains and a three-minute allowance for load-and-go connections to trains from Boston.

Figure 9: Conceptual Peabody Square Bus Shuttle Schedule: Summary

Peabody Square - Salem Depot Conceptual Weekday Shuttle Bus Schedule																
INBOUND	152	104	106	160	108	110	112	168	116	170	118	172	120	122	124	178
Peabody	6:10 AM	7:01 AM	7:40 AM	8:13 AM	8:43 AM	9:47 AM	11:28 AM	1:27 PM	2:18 PM	3:12 PM	3:58 PM	5:01 PM	5:37 PM	6:15 PM	7:43 PM	8:32 PM
North Station	6:49 AM	7:40 AM	8:22 AM	8:55 AM	9:31 AM	10:34 AM	12:14 PM	2:13 PM	3:05 PM	3:59 PM	4:45 PM	5:50 PM	6:25 PM	7:04 PM	8:29 PM	9:18 PM
Travel Time	0:39	0:39	0:42	0:42	0:48	0:47	0:46	0:46	0:47	0:47	0:47	0:49	0:48	0:49	0:46	0:46
OUTBOUND	101	191	103	105	159	161	163	111	113	193	119	173	175	177	125	
North Station	6:39 AM	7:08 AM	7:50 AM	8:35 AM	9:40 AM	11:20 AM	1:20 PM	1:50 PM	3:35 PM	4:40 PM	5:30 PM	6:05 PM	6:45 PM	7:35 PM	8:45 PM	
Peabody	7:20 AM	8:01 AM	8:39 AM	9:20 AM	10:25 AM	12:05 PM	2:07 PM	2:44 PM	4:24 PM	5:29 PM	6:11 PM	6:52 PM	7:31 PM	8:19 PM	9:31 PM	
Travel Time	0:41	0:53	0:49	0:45	0:45	0:45	0:47	0:54	0:49	0:49	0:41	0:47	0:46	0:44	0:46	

The simple Peabody Shuttle provides 31 connections to North Station trains: 16 inbound and 15 outbound. The average scheduled travel time between Peabody and North Station, including the 5-minute inbound transfer or the 3-minute outbound transfer, would be 46 minutes. The minimum travel time would be 39 minutes when connecting to outbound express trains. The longest scheduled travel time would be 54 minutes.

Due to the longer running times on the roadway between Peabody and Salem, the typical transit trip between Peabody Square and North Station would be 46 minutes – 15% longer than the 40-minute rail travel time average.

Table 4.3 Bus and Rail Shuttle Service Summary

Shuttle Service	Peabody Bus	Peabody Rail	Danvers Rail	Centennial Rail
Length (Miles)	2	2.0	5.1	4.6
Travel Time (Minutes)	7 to 12	4	10	10
Intermediate Stops	0	0	2	2
Weekday Peabody Connections to Boston	31	36	34	34
<i>Trip Durations b/w Peabody Square and North Station (Minutes)</i>				
Average	46	40	40	40
Minimum	39	33	36	36
Maximum	54	39	49	49

4.3 Potential Operators

The array of rail and bus shuttle alternatives described above could be operated by a variety of entities for the benefit of Peabody residents. An overarching consideration in selecting an operator is the small scale of the enterprise. With only one vehicle and one operator in service at any time, the Peabody Trolley would be a very small operation with no economies of scale.

Regardless of the scale of the operation, a transit enterprise needs to provide training, spare crew and maintainers to cover vacations, absences and training, supervision, testing, administration, fare collection. A small standalone enterprise operating the Trolley would need to provide these functions internally or manage a network of subcontractors to provide the necessary support. In contrast, a larger existing transit operation could take on the Trolley more gracefully using its existing workforce and management structures to provide spare staff, supervision, administration and management.

These considerations lead the study team to recommend that the City of Peabody partner with established local rail and bus operating entities to operate and manage the service.

4.3.1 Massachusetts Bay Transportation Authority

The T owns the rail right of way that would carry either the Peabody or Danvers rail shuttle; Pan Am owns the rail right of way that would carry the Centennial shuttle west of Peabody Square. The T also manages all local passenger rail service in Massachusetts. It operates the nation's largest light rail network and the fifth largest commuter railroad. The MBTA clearly has the experience, staff and resources to seamlessly absorb a 2-to 5-mile one-car rail shuttle or a 2-mile bus route into its portfolio of services with the little duplication or additional overhead in providing management functions.

The MBTA contracts with an outside carrier to manage its commuter rail operator. Any rail shuttle could be operated in whole, or in part, under that competitively bid contract.

4.3.2 Private Contractors

Boston is fortunate to be home to two of the US' larger established private passenger rail operators. Either of these two firms would be good candidates to support or collaborate with the MBTA to provide service.

- **Keolis North America** is the Western Hemisphere operation of a global public transport firm headquartered in France. Domestically it operates the commuter rail service of the MBTA and a smaller two-line network in Northern Virginia. It also operates a light rail line in Ontario. Keolis is also the contract operator for a number of bus transit systems in the US. Worldwide, Keolis operates systems in over 15 countries and claims to be the largest light rail operator in the world. For more information, contact:

Clement Michel, Regional Director, Keolis North America
470 Atlantic Avenue, 5th Floor, Boston Massachusetts 02110
clement.michel@keolisna.com

- **Alternate Concepts Incorporated** – Founded in 1989 by former MBTA General Manager Jim O'Leary, Alternate Concepts, Inc. (ACI) offers transportation operations and maintenance across the United States. It operates the "Tren Urbano" mass transit rail system in Puerto Rico, the light rail system in Phoenix, Arizona and the commuter railroad in Denver. It has also been contracted to operate a new light rail line under construction in Maryland. Prior to the award of the MBTA commuter rail contract to Keolis in 2014, ACI was a key member of the consortium that operated the MBTA commuter railroad. ACI's sister firm, Paul Revere Transportation, is also Boston's leading provider of private shuttle bus operations including MassPort's Logan circulation and Logan Express buses, the portfolio of services offered at the Longwood Medical Area and various contracts for the MBTA and other public agencies and private firms.

James O'Leary, President, Alternate Concepts Incorporated
1 Liberty Square, Suite 430, Boston, Massachusetts 02109
617-523-3131 | alternateconceptsinc.com

Both ACI and Keolis have the experience, background and resources to operate the Peabody Trolley under contract to the MBTA or the City of Peabody.

5 Evaluation of Alternatives

This chapter describes the estimates of the costs and benefits of developing and operating the five service alternatives:

1. Peabody Rail Shuttle-Diesel
2. Peabody Rail Shuttle-Electric
3. Danvers Rail Shuttle
4. Centennial Rail Shuttle
5. Peabody Bus Shuttle

The chapter also compares and contrasts the alternatives relative to their likely operating costs, capital costs, and ridership potential. The chapter concludes with a description of institutional and regulatory issues that the City of Peabody should be aware of moving forward.

5.1 Capital Requirements and Estimated Capital Costs

This section describes the infrastructure and rolling stock investment that would be required for each service alternative and then provides a preliminary estimate of the expenditures that would be required.

5.1.1 Peabody Rail Shuttle

Among rail service alternatives, the 1.9 mile Peabody rail shuttle would require the least investment in infrastructure.

- **Track** – 1.7 miles of rehabilitated track and 0.35 miles of new or replacement track. New turnouts would be required at the entrance to the Salem Transfer station to isolate it from the freight operations and at Peabody Junction allowing the Peabody Square station to be built off of tracks shared with freight trains. Up to two turnouts would be required at the train maintenance and storage facility. Electric switch locks would allow train dispatchers to positively separate the passenger only tracks from the tracks shared with freight services. The recommended program of track rehabilitation and replacement is diagrammed in Figure 1.
- **Signals** – The shuttle service would be operated under non-signaled DCS (manual train orders) operating rules. During passenger train hours, exclusive use of the track would be given to the shuttle. Track inspections and the freight train would operate during times when the passenger train service is suspended and locked behind one of the remote controlled switches controlled by the train dispatcher. Automatic highway warning device signals would be necessary to warn motorists at the six crossings traversed by the passenger railroad. An allowance of \$150k per track mile is included for positive train control if federal regulators determine that it is required for this operation.

- **Stations** – The Peabody Shuttle would require two new station platforms: one in Salem and the other in Peabody Square. Each platform would be approximately 100' long, 10' wide and 14" to 26" high depending upon the vehicle selection. The platform would include a 75' canopy, three benches, lighting, variable message signs, a public announcement system, and fare vending equipment. Up to 200' of 4'-wide walkways would connect passengers to nearby streets and commuter rail platforms.
- **Bridges** – Some of the four bridges supporting the railway over the North River and Proctor Brook are more than 100 years old. Three are fabricated entirely of wood. These bridges would be carefully inspected and rated before any passenger service would be operated. The study team's preliminary assessment for each of the four bridges is found below.
 - Bridge 1.78 is a ~20' steel bridge on concrete abutments with a wooden tie superstructure. The majority of the steel appears to be in satisfactory condition, however, the bottom portions of the beams will need rehabilitation. Inspection and load rating would need to be completed to confirm additional rehabilitation requirements. It is likely that substructure work will be required. The study team assumes that minor patching of the abutments is all that is required, as well as minor rehabilitation of the bottom portions of the steel bottom flanges. (\$100,000).
 - Bridge 1.48, a ~35' wooden bridge on stone abutments, is relatively long for single span timbers. Overall the bridge appears to be in fair condition but an inspection and load rating would be needed to confirm load rating capacity. Deteriorated timbers must be replaced. The substructure may require rehabilitation. The study team assumes that rehabilitation and strengthening of the timber beams will be required, (\$100,000).
 - Bridge 1.10 is also a ~35' wooden bridge on stone abutments, but its support is supplemented with two wooden piers. The study team did not confirm the condition of the pier bents (along with scour or undermining). An inspection and load rating would need to be completed; but in general, the bridge seems to be in fair condition. This type of

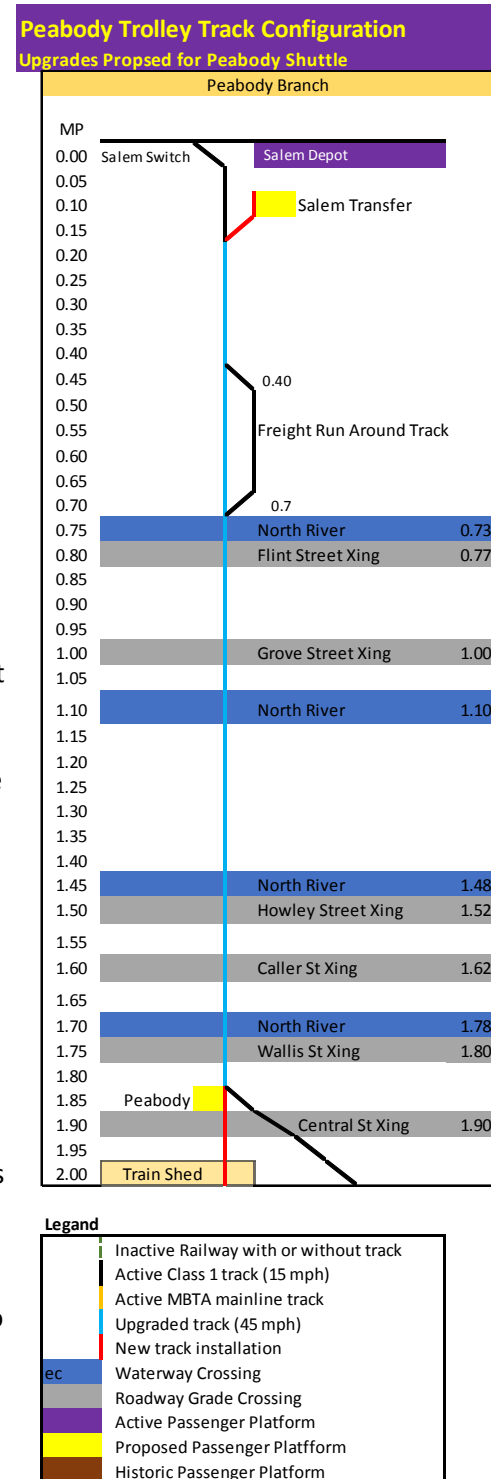


Figure 1

superstructure is relatively simple to augment with additional timber girders to increase strength, if needed. The team assumes that the timber piers will require no rehabilitation but scour protection would be required for the footings; the abutments require some minor rehabilitation; and the superstructure requires strengthening with additional timber beams. (\$300,000).

- Bridge 0.73 is another ~35' wooden bridge on stone abutments with two wooden piers. Based on the surface conditions of the timber and the debris present it appears that the hydraulic opening of the bridge is insufficient. A profile increase is indicated. Under these circumstances, the entire structure and piers should be replaced. The least costly rehabilitation would upgrade the existing substructures to accept a new single span superstructure (\$450,000).
- **Vehicle Storage and Maintenance** – The passenger vehicles will need a facility where they are stored, cleaned and maintained. The study team recommends a 120' long two-track building with a 22' paved center aisle for the movement of cranes, jacks and maintenance equipment to train side. The facility would include 5 electric jacks, 2 portable cranes and a small machine shop for the repair and fabrication of parts. Heavy repairs (e.g. accident damage, overhauls) might require one car to be occasionally trucked to a back shop repair facility with more specialized and heavier repairs. A site for the storage and maintenance facility would require a parcel at least 300' long and 65' wide to accommodate turn-outs and the building. Acquisition of such a parcel was not included in cost estimates. Conceptual plans for two car barn alternatives are found in Appendix C.
- **Electrification** – If an electric light rail car is selected for the Peabody Shuttle service, all passenger tracks would require electric wires suspended overhead providing access to 600 Volt DC traction power. Electrification will also require a traction power substation to convert the electrical energy from the local electric grid to the 600 Volt DC current used to energize the overhead wires. The overhead wires (catenary system) and substation would not be required for a diesel-powered passenger car. Acquisition of a parcel for the substation was not included in cost estimates. It is possible that the substation could be accommodated within the existing MBTA right of way. For greatest efficiency, the substation should be sited near the midpoint of the two-mile electric trolley line.
- **Vehicles** - The Peabody Shuttle would require one vehicle for daily operations with another held in spare reserve for maintenance and to respond to in-service failures. The vehicles would be stored and maintained. Based on recent purchases of passenger rail rolling stock the projected cost to purchase new diesel or electric cars would be roughly the same.

Preliminary estimates of the funds that would be required to design, purchase, install and commission the required infrastructure and rolling stock for the Peabody Shuttle are shown below.

Estimated Expenditures for Peabody Shuttle Alternative (Diesel)

Infrastructure Element	Units	Qty	Unit Price (000's)	Extension	Comments
Track					
Rehabilitated Track	Miles	1.70	\$1,000.0	\$1,700	Resurface, Spot Rail and Tie Replacement
New or Replaced Track	Miles	0.35	\$1,250.0	\$438	New Ties, Ballast, Drainage
Turnouts #10	Each	4	\$200.0	\$800	
Electric Locks	Each	2	\$75.0	\$150	
Structures					
Passenger Stations	Each	2	\$619.9	\$1,240	Platforms, Canopy, Furniture etc
Train Shed	Sq FT	4500	Lump	\$1,155	100*45 building (See separate sheet)
Bridge 1.85	Each	0	\$300.0	\$0	Up to 20 feet long
Bridge 1.78	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 14.8	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 1.10	Each	1	\$300.0	\$300	Up to 20 feet long
Bridge 0.73	Each	1	\$450.0	\$450	35-40 feet long
Cranes River Bridge	Each	0	\$1,000.0	\$0	150+ feet long
Waters River Bridge	Each	0	\$4,000.0	\$0	150+ feet long
Signal					
Automatic Highway Warning Devices	Each	6	\$400	\$2,400	Four Quadrant Quiet Zone
Positive Train Control	Miles	1.70	\$150	\$255	
Direct Total				\$9,087	
Culverts and Retaining Walls				\$273	3%
Environmental Allowance				\$273	3%
Design and Construction Phase Services				\$1,363	15%
Railroad Services and Design Review				\$273	3%
Subtotal				\$11,268	
Contingency				\$3,944	35%
Infrastructure Total				\$15,212	
Vehicles					
Vehicle Main Equip (Allowance)	Lump	1	\$525.0	\$525	Electric Jacks, Portable cranes, Machine Shop
MBTA Type 9 Car or Similar	Each	0	\$6,000.0	\$0	Per CH2M Data Sources
Diesel Multiple Units	Each	2	\$7,500.0	\$15,000	Stadler GTW 6/2
Direct Total				\$15,525	
Design and Construction Phase Services				\$2,329	15%
Subtotal				\$17,854	
Contingency				\$1,785.38	10%
Vehicle Total				\$19,639	
Grand Total				\$34,851	

Estimated Expenditures for Peabody Shuttle Alternative (Electric)

Infrastructure Element	Units	Qty	Unit Price (000's)	Extension	Comments
Track					
Rehabilitated Track	Miles	1.70	\$1,000.0	\$1,700	Resurface, Spot Rail and Tie Replacement
New or Replaced Track	Miles	0.35	\$1,250.0	\$438	New Ties, Ballast, Drainage
Turnouts #10	Each	4	\$200.0	\$800	
Electric Locks	Each	2	\$75.0	\$150	
Structures					
Passenger Stations	Each	2	\$619.9	\$1,240	Platforms, Canopy, Furniture etc
Train Shed	Sq FT	4500	Lump	\$1,155	100*45 building (See separate sheet)
Bridge 1.85	Each	0	\$300.0	\$0	Up to 20 feet long
Bridge 1.78	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 14.8	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 1.10	Each	1	\$300.0	\$300	Up to 20 feet long
Bridge 0.73	Each	1	\$450.0	\$450	35-40 feet long
Cranes River Bridge	Each	0	\$1,000.0	\$0	150+ feet long
Waters River Bridge	Each	0	\$4,000.0	\$0	150+ feet long
Signal					
Automatic Highway Warning Devices	Each	6	\$400	\$2,400	Four Quadrant Quiet Zone
Positive Train Control	Miles	1.70	\$150	\$255	
Direct Total				\$9,087	
Culverts and Retaining Walls				\$273	3%
Environmental Allowance				\$273	3%
Design and Construction Phase Services				\$1,363	15%
Railroad Services and Design Review				\$273	3%
Subtotal				\$11,268	
Contingency				\$3,944	35%
Infrastructure Total				\$15,212	
Vehicles					
Vehicle Main Equip (Allowance)	Lump	1	\$525.0	\$525	Electric Jacks, Portable cranes, Machine Shop
MBTA Type 9 Car or Similar	Each	2	\$6,000.0	\$12,000	Per CH2M Data Sources
Diesel Multiple Units	Each	0	\$7,500.0	\$0	Stadler GTW 6/2
Direct Total				\$12,525	
Design and Construction Phase Services				\$1,879	15%
Subtotal				\$14,404	
Contingency				\$1,440.38	10%
Vehicle Total				\$15,844	
Electric Traction Option					
Overhead Wire Catenary System	Each	1.00	\$1,267.3	\$1,267	Support Poles, hangers and wires
Electric Substation	Each	1.00	\$2,000.0	\$2,000	Prefabricated Substation
Direct Total				\$3,267	
Environmental Allowance				\$98.02	3%
Design and Construction Phase Services				\$490	15%
Railroad Services and Design Review				\$98	3%
Subtotal				\$3,953	
Contingency				\$1,384	35%
Electric Traction Total				\$5,337	
Grand Total (Electric)				\$36,394	

5.1.2 Danvers Shuttle

The five-mile Danvers Shuttle would require more investment in infrastructure. In particular, it would require more replacement track, upgrade or replacement of two more bridges, up to two more passenger stations, and more grade crossing improvements. However, given that it would make use of otherwise idle time on the Peabody Shuttle and that it would expand the passenger market to another major municipality, it is worth consideration.

- **Track** – The Danvers Shuttle would require the same track investments required for the Peabody Shuttle plus an additional 2.85 miles of replacement north of Peabody Square. The recommended program of additional track rehabilitation and replacement is diagrammed in Figure 2.
- **Signals** – Beyond the investments required for the Peabody Shuttle, the Danvers service would need upgrades at three additional grade crossing. An allowance of \$150k per track mile is included for positive train control if federal regulators determine that it is required for this operation.
- **Stations** – The Danvers shuttle would require one or two additional station platforms: one in Danvers and potentially one in Danversport.
- **Bridges** – In addition to the bridges between Peabody Square and Salem Depot, the Danvers Shuttle would require replacement of the Waters River Bridge and upgrades to the Crane River Bridge.
 - Waters River Bridge is a 150' wooden structure damaged by fire in 1983. It is assumed that no portion of the structure can be reused. The height of the timber bents cannot support the longitudinal braking or traction loads required for modern railway bridges. Environmentally, a single span truss bridge may be the favored replacement design reducing the need for piers in the river bed and maximizing flow under the bridge. The budgeted amount for construction of this bridge should be \$4 million.



Figure 2

- Cranes River Bridge makes a 45' span of the Cranes River with steel beams supporting wooden ties. The beams are supported by stone abutments and single wooden center pier. Several

options would be considered to restore this bridge for active railway service. One option would rehabilitate the abutments and superstructure while replacing the central pier. Another option would rehabilitate the abutments and replace the superstructure with a span that would not require a pier. In either case, the construction cost would be approximately \$1 million.

- **Vehicle Storage and Maintenance** – The vehicle storage and maintenance requirements for the Danvers Shuttle are identical to the Peabody Shuttle.
- **Electrification** – The study team did not estimate the cost of electrifying the Danvers Shuttle service.
- **Vehicles** - The vehicle requirements for the Danvers Shuttle are identical to the Peabody Shuttle.

Preliminary estimates of the funds that would be required to design, purchase, install and commission the required infrastructure and rolling stock for the Danvers Shuttle are shown below.

Estimated Expenditures for Danvers Shuttle Option

Infrastructure Element	Units	Qty	Unit Price (000's)	Extension	Comments
Track					
Rehabilitated Track	Miles	1.70	\$1,000.0	\$1,700	Resurface, Spot Rail and Tie Replacement
New or Replaced Track	Miles	3.20	\$1,250.0	\$4,000	New Ties, Ballast, Drainage
Turnouts #10	Each	4	\$200.0	\$800	
Electric Locks	Each	2	\$75.0	\$150	
Structures					
Passenger Stations	Each	4	\$619.9	\$2,480	Platforms, Canopy, Furniture etc
Train Shed	Sq FT	4500	Lump	\$1,155	100*45 building (See separate sheet)
Bridge 1.85	Each	0	\$300.0	\$0	Up to 20 feet long
Bridge 1.78	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 14.8	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 1.10	Each	1	\$300.0	\$300	Up to 20 feet long
Bridge 0.73	Each	1	\$450.0	\$450	35-40 feet long
Cranes River Bridge	Each	1	\$1,000.0	\$1,000	150+ feet long
Waters River Bridge	Each	1	\$4,000.0	\$4,000	150+ feet long
Signal					
Automatic Highway Warning Devices	Each	9	\$400	\$3,600	Four Quadrant Quiet Zone
Positive Train Control	Miles	4.90	\$150	\$735	
Direct Total				\$20,570	
Culverts and Retaining Walls				\$617	3%
Environmental Allowance				\$617	3%
Design and Construction Phase Services				\$3,085	15%
Railroad Services and Design Review				\$617	3%
Subtotal				\$25,507	
Contingency				\$8,927	35%
Infrastructure Total				\$34,434	
Vehicles					
Vehicle Main Equip (Allowance)	Lump	1	\$525	\$525	Electric Jacks, Portable cranes, Machine Shop
Diesel Multiple Units	Each	2	\$7,500.0	\$15,000	Stadler GTW 6/2
Direct Total				\$15,525	
Design and Construction Phase Services				\$2,329	15%
Subtotal				\$17,854	
Contingency				\$1,785.38	10%
Vehicle Total				\$19,639	
Grand Total				\$54,073	

5.1.3 Centennial Shuttle

The 4.6-mile Centennial Shuttle would require more investment in infrastructure than the shorter Peabody rail service. Similar to the Danvers Shuttle alternative, it would require more rehabilitated and replacement track, upgrades to one more bridge, up to two more passenger stations, and more grade crossing improvements.

- **Track** – The Centennial Shuttle would require the same track investments required for the Peabody Shuttle plus an additional 1.5 miles of additional track rehabilitation and 0.85 miles of track replacement west of Peabody Square. The recommended program of additional track rehabilitation and replacement is diagrammed in Figure 3.
- **Signals** – Beyond the investments required for the Peabody Shuttle, the Centennial service would need upgrades at seven additional grade crossings. An allowance of \$150K per track mile is included for positive train control if federal regulators determine that it is required for this operation.
- **Stations** – The Centennial Shuttle would require one or two additional station platforms: one at Summit Street and one at First Avenue.
- **Bridges** – In addition to the bridges between Salem and Peabody Square, the Centennial Shuttle crosses the Proctor Brook on a wooden trestle just west of Lowell Street. Bridge 1.85 is 50' timber open deck bridge. Fifty feet is an extremely long span for a timber bridge. But assuming that only minor substructure rehabilitation is necessary and that the superstructure can be rehabilitated and strengthened with additional timber stringers the cost for upgrade would be \$300,000.
- This bridge would need to be inspected and rated before any passenger service could be operated. An allowance is provided for the rehabilitation, upgrade or replacement of the wooden bridge.
- **Vehicle Storage and Maintenance** – The vehicle storage and maintenance requirements for the Centennial Shuttle are identical to the Peabody Shuttle.
- **Electrification** – The study team did not estimate the cost of electrifying the Centennial Shuttle service.

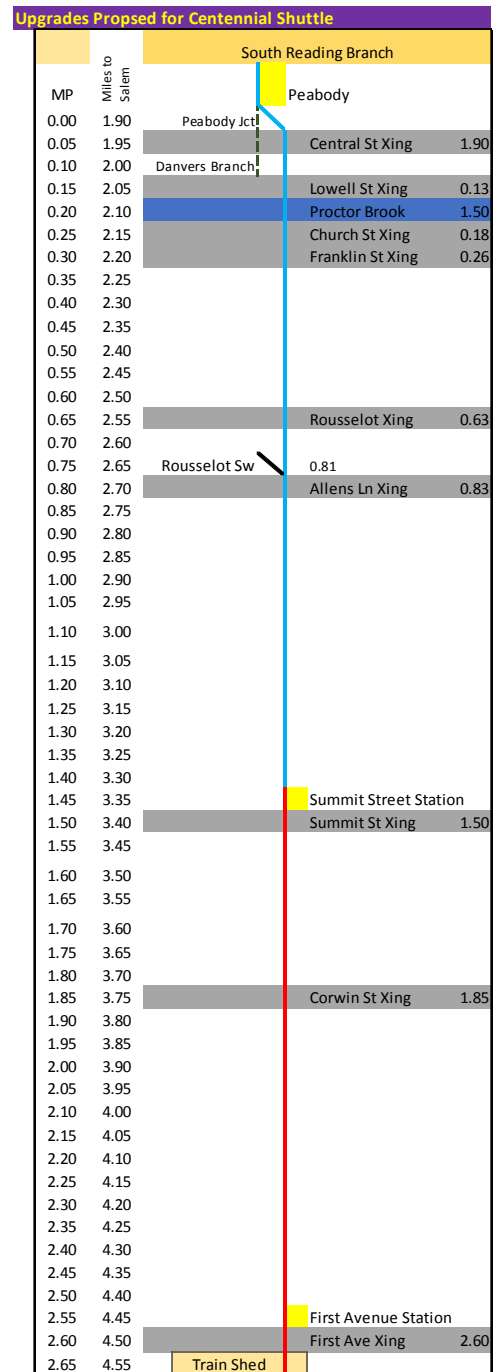


Figure 3

- **Vehicles** - The vehicle requirements for the Centennial Shuttle are identical to the Peabody Shuttle.

Preliminary estimates of the funds that would be required to design, purchase, install and commission the required infrastructure and rolling stock for the Centennial Shuttle are shown below.

Estimated Expenditures for Centennial Shuttle Alternative

<i>Infrastructure Element</i>	<i>Units</i>	<i>Qty</i>	<i>Unit Price (000's)</i>	<i>Extension</i>	<i>Comments</i>
Track					
Rehabilitated Track	Miles	3.20	\$1,000.0	\$3,200	Resurface, Spot Rail and Tie Replacement
New or Replaced Track	Miles	1.20	\$1,250.0	\$1,500	New Ties, Ballast, Drainage
Turnouts #10	Each	4	\$200.0	\$800	
Electric Locks	Each	2	\$75.0	\$150	
Structures					
Passenger Stations	Each	4	\$619.9	\$2,480	Platforms, Canopy, Furniture etc
Train Shed	Sq FT	4500	Lump	\$1,155	100*45 building (See separate sheet)
Bridge 1.85	Each	1	\$300.0	\$300	Up to 20 feet long
Bridge 1.78	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 14.8	Each	1	\$100.0	\$100	Up to 20 feet long
Bridge 1.10	Each	1	\$300.0	\$300	Up to 20 feet long
Bridge 0.73	Each	1	\$450.0	\$450	35-40 feet long
Cranes River Bridge	Each	0	\$1,000.0	\$0	150+ feet long
Waters River Bridge	Each	0	\$4,000.0	\$0	150+ feet long

Signal

Automatic Highway Warning Devices	Each	13	\$400	\$5,200	Four Quadrant Quiet Zone
Positive Train Control	Miles	4.40	\$150	\$660	
Direct Total				\$16,395	
Culverts and Retaining Walls				\$492	3%
Environmental Allowance				\$492	3%
Design and Construction Phase Services				\$2,459	15%
Railroad Services and Design Review				\$492	3%
Subtotal				\$20,330	
Contingency				\$7,115	35%
Infrastructure Total				\$27,445	

Vehicles

Vehicle Main Equip (Allowance)	Lump	1	\$525.0	\$525	Electric Jacks, Portable cranes, Machine Shop
Diesel Multiple Units	Each	2	\$7,500.0	\$15,000	Stadler GTW 6/2
Direct Total				\$15,525	
Design and Construction Phase Services				\$2,329	15%
Subtotal				\$17,854	
Contingency				\$1,785.38	10%
Vehicle Total				\$19,639	
Grand Total				\$47,084	

5.1.4 Peabody Bus Shuttle

Among all service alternatives, the Peabody Square-Salem Depot Bus shuttle would require the least investment in infrastructure and vehicles. This alternative would use existing roadways shared with other automotive traffic and call on the existing modern bus depot at the Salem commuter rail station. It would be possible that operations in Peabody Square could be staged on the street but an off-street location for buses to wait for the next trip and for passengers to pay fares, queue for buses and receive passenger information is recommended. The off-street location would be designed to be an attractive community landmark built on the publicly owned parcel where the two branches of the railroad split immediately east of Central Street. It would feature two bus berths, one for the rail depot shuttle and the other for existing MBTA routes 434, 435 and 465. Buses would enter the facility from Central Street and exit the facility on Wallis via a 700' one-way (eastbound) busway constructed immediately north of the existing rail tracks. The bus platform would be sheltered with seating, fare vending equipment, variable message signs for passenger information and fully compliant with ADA and Universal Design guidelines.

- **Busway** – Approximately 700' of busway would be paved with curbs and drainage immediately north of the existing tracks.
- **Stations** – The Peabody Transit Center would provide two connected bus berths with canopies, lighting, furniture and support equipment as described above.
- **Vehicle Storage and Maintenance** – The bus vehicles would be stored and maintained at the MBTA's existing Lynn Garage.
- **Vehicles** – The Peabody Bus Shuttle would require one vehicle for daily operations drawn from the MBTA fleet maintained in Lynn. A spare vehicle would be available when necessary from the pool of spares at the Lynn Garage. The MBTA's most recent bus procurement paid \$284 million for 345 vehicles yielding an average cost of \$823,000 per bus.

Preliminary estimates of the funds that would be required to design, purchase, install and commission the required infrastructure and vehicles for the Peabody Bus Shuttle are shown below.

Estimated Expenditures for Peabody Square - Salem Depot Shuttle Bus Option

<i>Infrastructure Element</i>	<i>Units</i>	<i>Qty</i>	<i>Unit Price (000's)</i>	<i>Extension</i>	<i>Comments</i>
Busway					
Roadway construction	Miles	0.15	\$2,000.0	\$303	Subgrade, drainage, paving and curbs
Structures					
Bus Berths and Platforms	Each	1	\$619.9	\$620	Platforms, Canopy, Furniture, Signage etc
Direct Total				\$923	
Environmental Allowance				\$28	3%
Design and Construction Phase Services				\$111	12%
Subtotal				\$1,061	
Contingency				\$371	35%
Infrastructure Total				\$1,433	

Vehicles					
Bus	Each	1.15	\$820.3	\$943	40' Hybrid or Electric Low Floor Bus
Direct Total				\$943	
Design and Construction Phase Services				\$142	15%
Subtotal				\$1,085	
Contingency				\$54.24	5%
Vehicle Total				\$1,139	

Grand Total	\$2,572
--------------------	----------------

5.1.5 Capital Cost Summary

Forecast capital costs for each of the four rail and one bus service alternatives are summarized in the table to the right. The Peabody Rail Shuttle is forecast to cost \$34M to \$37M depending upon whether the trolley is diesel or electric. Extending a diesel rail trolley west to Centennial or north to Danvers would add \$12M to \$19M to the costs for infrastructure upgrades.

Estimated Capital Expenditures for Peabody Trolley Development Options (000's)

	Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
Guideway	\$3,088	\$3,088	\$6,650	\$5,650	\$303
Stations and Structures	\$3,345	\$3,345	\$9,585	\$4,885	\$620
Signals	\$2,655	\$2,655	\$4,335	\$5,860	
Electrification		\$3,267			
Additives	\$2,181	\$2,867	\$4,937	\$3,935	\$138
Contingency	\$3,944	\$5,328	\$8,927	\$7,115	\$371
Vehicles	\$15,525	\$12,525	\$15,525	\$15,525	\$943
Additives	\$2,329	\$1,879	\$2,329	\$2,329	\$142
Contingency	\$1,785	\$1,440	\$1,785	\$1,785	\$54
Grand Total	\$34,851	\$36,394	\$54,073	\$47,084	\$2,572

The bus shuttle would require much less capital expenditure. Investments would be limited to \$1.4M for a short busway and transit center. A new bus with an allowance for spares would add another \$1.1M.

5.2 Estimated Operating Costs

This section outlines the service parameters that would affect the cost of running one the five service alternatives. Four broad categories of operating cost are considered.

- **Transportation** – Operating crews with spares, dispatch, train control and fuel
- **Maintenance of Equipment (MoE)** – Labor and materials to maintain and clean vehicles
- **Maintenance of Way (MoW)** – Maintenance of track, drainage, crossings, bridges, switches, train control systems, stations, car barns
- **Administration** – Claims and legal, customer relations, security, payroll, revenue, purchasing, accounting and finance, human resources, training, safety and employee certification, etc.

The operating cost estimates in this report reflect only weekday operations. Weekend and holiday services would add significantly to the costs for transportation resources including crews and fuel and the costs for servicing rolling stock. The various service alternatives are quite similar with respect to most operating parameters that drive transportation costs, as shown in the table below.

Peabody Trolley Operating Parameters by Service Alternative	One Way Trip Mileage	Weekday Vehicle Trips	Weekday Revenue Vehicle Miles	First Trip DEPT	Last Trip ARRV	Weekday Vehicle Hours
Rail						
Peabody Shuttle Diesel	1.85	42	77.7	6:13	21:26	16:13
Peabody Shuttle Electric	1.85	42	77.7	6:13	21:26	16:13
Danvers Shuttle	5.10	38	193.8	6:07	21:32	16:25
Centennial Shuttle	4.60	38	174.8	6:07	21:32	16:25
Bus						
Peabody Salem Bus Shuttle	2.0	34	68	6:10	21:31	16:21

By contrast, the extent to maintain the infrastructure and fleet required to operate one of the five alternatives varies more widely, as shown below.

Peabody Trolley Maintenance Elements by Service Alternative	Rail Cars	Buses	Station Platforms	Guideway Miles	Railway Bridges	Highway Rail Crossings	Car Barns	Miles of Catenary
Rail								
Peabody Shuttle Diesel	2	0	2	1.85	4	6	1	0
Peabody Shuttle Electric	2	0	2	1.85	4	6	1	1.85
Danvers Shuttle	2	0	4	5.10	6	9	1	0
Centennial Shuttle	2	0	4	4.60	5	13	1	0
Bus								
Peabody Salem Bus Shuttle	0	1.15	1	0.15	0	0	0	0

5.2.1 Methodology and Assumptions

The operating costs were estimated using the following methods and assumptions. All costs for transportation, maintenance of equipment and administration are drawn from 2016 agency reports to the Federal Transit Administration, escalated to 2018. Estimated maintenance of way costs were derived from MBTA and Keolis commuter rail budget documents.

5.2.2 Transportation

- **Train Operators** – Regardless of the motive power (diesel or electric), the rail vehicles would be operated like “trolley” cars with a single person crew. Fares would be collected via the “proof-of-payment” fare collection scheme that the MBTA is planning to roll out in 2020. Under this regime, fares would be purchased from a vending machine on the station platform or via smart phone. Fares would be randomly checked onboard but no fares would be collected enroute. Forecast cost for staffing and supervision would be based on MBTA reported light rail (Green Line) transportation staffing expenditures per vehicle hour of service. The \$33.42 hourly estimate includes wages, fringe, benefits, overtime, uniforms and train supplies.
- **Bus Operators** – For the purposes of this cost estimate it is presumed that the MBTA would operate the Peabody-Salem Shuttle Bus. The MBTA’s current fully loaded rate for bus operations is \$31.97.
- **Propulsion Power** – The fuel consumption rates and data sources for the various estimates vary with the mode. MBTA fuel costs for light rail electricity average \$0.52 per mile. MBTA bus fuel costs average \$0.27 per mile. Fuel costs for five DMU fleets in Portland, New Jersey, California, Texas average \$0.35 per mile.

5.2.3 Maintenance of Equipment

The proposed shuttle services all reflect relatively low mileage duty cycles. But maintenance, including cleaning, inspections, and replacement of worn parts, will be required daily. Estimated MoE costs are based on annual reported MoE cost per vehicle for MBTA light rail (\$208,393), MBTA bus (\$111,540) and US DMU (\$233,193) fleets.

5.2.4 Maintenance of Way

Guideway Maintenance - It is assumed that maintenance for the track, bridges, highway grade crossings, signals and bridges would be assigned to MBTA commuter contract staff based in Lynn, Salem and Newburyport. Twenty foremen, maintainers, drivers, operators, and welders are assigned over these three maintenance bases to inspect and maintain the 52 route miles that comprise the MBTA's Rockport and Newburyport Branches. Under federal railway regulations, passenger tracks must be inspected twice each week. All signals and grade crossing warning systems must be inspected monthly. Stations are cleaned at least twice each week. Bridges are inspected regularly. The current team of 20 staff cover an extensive array of railway infrastructure.

Two staff are dedicated to track patrols, eight to track maintenance, six to signals and six to bridges and buildings.

Railway Assets	Newburyport/Rockport Line	Peabody Shuttle	Danvers Shuttle	Centennial Shuttle
Track Miles	82.8	1.85	5.1	4.6
Mainline Switches	57	4	4	4
Grade Crossings	54	6	9	13
Interlockings	14	0	0	0
Station Platforms	27	2	4	4
MoE Bases	27	1	1	1
Undergrade Bridges	31	4	5	6

Given the scope of their current workload, it could be expected that one additional signal maintainer for all of the rail alternatives and that one additional track or bridge and building maintainer would be required for the longer rail services. The signal maintainer would add \$100,633 for labor and fringes, \$13,428 for materials and \$12,305 for work equipment. A composite track, bridge and building maintainer would add \$106,971 for labor and fringes, \$38,644 for materials and \$4,857 for work equipment.

It is estimated that the bus berths and 700-foot busway recommended for the shuttle bus alternative would require two hours weekly to clear snow, sweep platforms, empty trash receptacles, clean graffiti, and change light bulbs, for a cost of approximately \$8,000 per year.

Electric Traction Maintenance – The MBTA's Power Department maintains 46 traction substations, 3 switching stations, two jet turbines, 54 unit substations, 98 miles of overhead catenary wire with support poles and switches, and 800 mile of rapid transit power cable for a budget of approximately \$13.8 million per year. The study team estimates that adding a substation and overhead catenary system for an electric trolley would approximately \$208,000 to the Power Department's annual expenditures.

5.2.5 Administration

The MBTA's ratio of administrative support costs to direct operating expenditures is generally 15% and falls in line with general industry norms for the cost of claims and legal, customer relations, security, payroll, revenue, purchasing, accounting and finance, human resources, training, safety and employee certification.

5.2.6 Forecast Operating Costs

Based on the methods and assumptions described above, the study team's estimate of annual operating costs for each service alternative is listed in the table below.

Estimated Annual Operating Costs (000s)	Vehicle Operations	Vehicle Propulsion	Vehicle Maintenance	Guideway Maintenance	Power System Maintenance	Admin	Total Cost
Rail							
Peabody Shuttle Diesel	\$138	\$7	\$466	\$157		\$119	\$887
Peabody Shuttle Electric	\$138	\$10	\$417	\$157	\$208	\$143	\$1,072
Danvers Shuttle	\$139	\$17	\$466	\$307		\$148	\$1,078
Centennial Shuttle	\$139	\$16	\$466	\$307		\$147	\$1,076
Bus							
Peabody Salem Bus Shuttle	\$133	\$5	\$128	\$8		\$44	\$318

Asset Renewal – In addition to the cost of maintaining the capital assets necessary to operate the various shuttle alternatives, funds should be set aside to replace or renew the track, signals, bridges and vehicles at the end of their expected lives. Based on the estimated costs and expected asset lives of the various improvements that would be required, the annual suggested contribution to a “sinking fund” for each trolley service alternative is listed below.

Asset Renewal Factors (000s)							
	Expected Life (Years)	Annual Capital Renewal Factor	Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
Guideway	20	5%	\$221	\$221	\$477	\$405	\$22
Stations and Structures	50	2%	\$96	\$96	\$275	\$140	\$18
Signals	25	4%	\$152	\$152	\$249	\$336	
Electrification	30	3%		\$156			
Rail Cars	30	3%	\$104	\$137	\$236	\$188	
Buses	12	8%					\$7
Totals			\$574	\$763	\$1,236	\$1,069	\$46

5.3 Potential Ridership

All of the proposed Peabody Trolley service alternatives would provide faster and more frequent transportation service between Peabody and downtown Boston. While this study did not have time and resources to prepare a formal set of public transport forecasts, this portion of the report presents a range of potential ridership responses that might be expected from the introduction of a Peabody Trolley service. Should public officials choose to pursue development of a Peabody Trolley, more formal ridership forecasts should be prepared to vet the economic attractiveness of the service proposal.

Peers Approach - As discussed in Chapter 2, the comparison between Peabody and its Eastern Massachusetts peer communities with direct commuter rail service to Boston indicate that with a rail shuttle, the fraction of the Peabody workforce employed in Boston and Cambridge would substantially increase, as would the fraction of that commuter market that used commuter rail.

US Census Journey To Work Information for Peabody, Danvers and Peer Municipalities							
Municipality	Miles to Boston	AM Peak Highway Minutes to Boston		Commuter Rail Minutes to Boston	% of Workforce Employed in Boston or Cambridge	% of Boston and Cambridge Employees using Commuter Rail	% of Total Workforce Commuting by Rail
		Min	Max				
Peabody	20	55	100	0	9%	8%	1%
Danvers	23	55	110	0	9%	13%	1%
Peer Group Average	20	58	111	40	13%	35%	5%
Beverly	18	60	100	36	10%	46%	4%
Salem	17	50	110	32	14%	38%	5%
Andover	23	55	100	50	10%	35%	4%
Framingham	21	50	90	52	10%	16%	2%
Walpole	19	60	110	42	16%	42%	7%
Brockton	20	60	130	34	13%	16%	2%
Sharon	18	55	110	35	22%	57%	13%
Mansfield	25	65	120	42	8%	63%	5%
Abington	19	55	120	32	15%	22%	3%
Scituate	23	65	120	48	14%	15%	2%
Peer Group Maximum	25	65	130	52	22%	63%	13%
Peer Group Minimum	17	50	90	32	8%	15%	2%
Peer Group 25%tile	18	54	100	34	10%	16%	2%
Peer Group 50%tile	20	58	110	39	13%	37%	4%
Peer Group 75%tile	22	60	120	44	16%	49%	6%

The table above reports information concerning commuter markets for Peabody, Danvers and a set of ten peer communities with rail service.

The fractions of total workforce commuting by commuter railroad from Peabody and Danvers are both 1%. Among the peers the average fraction of the work force commuting by rail is 5%, with 2% at the 25% percentile, 4% at the 50% percentile, and 6% at the 75% percentile.

Applying those market shares to the rail service alternatives yields weekday demand forecasts as shown in the table below.

Rough Order of Magnitude Ridership Forecasts: Typical Inbound Weekday Boardings						
	Percentile	Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)*
Work Force		28,851	28,851	44,439	28,851	28,851
Lower Bound Forecast	25%	606	606	933	606	565
Mid Range Forecast	50%	1,157	1,157	1,782	1,157	1,079
Upper Bound Forecast	75%	1,668	1,668	2,570	1,668	1,556
* The shuttle bus trip would be 15% longer than the rail trips leading to a lower market share. A 45% bus travel elasticity adjustment was applied.						

Using this crude peer-based approach yields forecasts for the Peabody rail shuttles in the range of 600 to 1,700 weekday inbound boardings. Extending the shuttle to Centennial Park does not change the projections because it is a city-wide forecast. Extending the shuttle to Danvers would open a new travel market to the service, expanding the total ridership to 900 to 2,600 total weekday inbound boardings. Forecasts for the shuttle bus market are reduced somewhat to reflect the longer bus travel times.

Total travel on the shuttles would be roughly twice the forecast inbound boardings reflecting return passenger trips to Peabody and Danvers. Estimates of annual ridership can be derived by doubling the forecast number of inbound boardings then multiplying that weekday ridership estimate times 254 weekdays per year.

Cost Per Rider – The study team conservatively estimated the operating cost per annual rider by focusing on the lower bound ridership forecasts in the range of 565 to 933 inbound boardings per day. Applying the estimated annual operating costs to the lower bound boarding forecasts indicates that the operating cost per trip would lay in the range of \$1.08 to \$3.42 per passenger trip.

Estimated O&M Cost per Passenger Trip

	Peabody Rail Shuttle (Diesel)	Peabody Rail Shuttle (Electric)	Danvers Rail Shuttle (Diesel)	Centennial Rail Shuttle (Diesel)	Peabody Bus Shuttle (Hybrid)
Forecast Annual Passenger Trips	314,937	314,937	485,095	314,937	293,679
Forecast Annual O&M Cost (000s)	\$887	\$1,072	\$1,078	\$1,076	\$318
O&M Cost /Passenger Trip	\$2.82	\$3.41	\$2.22	\$3.42	\$1.08
Fare revenue per passenger trip	\$1.00	\$1.00	\$1.00	\$1.00	\$1.00
Cost Recovery Factor	0.36	0.29	0.45	0.29	0.92

On average, the MBTA typically recovers one-third of its costs through passenger fares. Assuming that the average revenue per passenger trip on the Peabody Shuttle would be \$1.00, the Peabody Diesel Rail Shuttle, the Danvers Rail Shuttle, and the Peabody Bus Shuttle would exceed the threshold of covering more than one third of their operating costs from passenger revenues. By this conservative rule of thumb, three of the five shuttle alternatives would yield a better return on operating expense than the typical MBTA transit service.

Example: Princeton Branch - It is interesting to compare the proposed Peabody rail shuttle with its closest US analog. The Princeton Branch is a commuter rail line owned and operated by New Jersey

Transit. The branch connects with NJT's Northeast Corridor for service to Manhattan's Penn Station. The branch line runs from Princeton Junction northwest to downtown Princeton with no intermediate stops. Also known as the "Dinky," the branch is served by special shuttle trains, making 41 connecting trips each weekday and making the 2.7-mile trip in 5 minutes along a single track. It is the shortest scheduled commuter rail line in the US.

Like Salem Depot, Princeton Junction is one of the most popular suburban stations in the NJT commuter rail network. Weekday boardings on the shuttle at Princeton are approximately 15% of the direct boardings made by park-n-ride patrons at Princeton Junction. Extending the 15% analogy to the approximately 2,400 weekday boardings at Salem Depot, it would be expected that trolley boardings at Peabody Square would be 360, for a total daily ridership of 720 passengers.

Further work required - As noted above, formal market forecasts were outside the scope of this initial feasibility study. These market forecasts should be confirmed or revised based on a more formal and extensive ridership forecast prepared by the Boston Region's Central Transportation Planning Staff or another team with more resources to conduct a detailed ridership study.

5.4 Institutional and Regulatory Issues

The MBTA is the public transportation agency serving and funded by the City of Peabody. It was created by the Commonwealth in 1964 to serve the cities and towns in Eastern Massachusetts. The T operates all of the Peabody's local bus service and manages the commuter rail service at Salem. The MBTA also owns the rail rights of way in Peabody, Salem and Danvers that would be used to develop and operate any rail shuttle service.

Pan Am operates freight service on the active portions of these lines under the "exclusive and perpetual freight easement" retained by its predecessor railroad - the Boston and Maine (B&M) - when the B&M sold all its rail assets in Massachusetts to the MBTA in the 1960's. As sole user of the "Danvers Branch" lines, Pan Am is presently responsible for their operation and maintenance. If passenger service were introduced on the line, maintenance and operating responsibility could be reassigned back to the MBTA or its commuter rail operations and maintenance contractor.

Under any circumstance, safety regulation for the line is the principal responsibility of the Federal Railroad Administration. The FRA is the lead safety agency for all general-purpose railroads in the nation. The FRA's purview does not extend to local transit services like the MBTA's Green and Blue Lines since they are not connected to the national network of conventional railroads. The FRA has stiff regulations regarding the design of rolling stock operated on the lines that it oversees. Light rail cars and light diesel cars do not meet those design criteria, but mechanisms and policies have been developed to allow light passenger cars to share track with freight operations on lightly used freight branch lines like the ones in Peabody.

This chapter provides background and context surrounding the historic and current regulations that a Peabody rail trolley sharing track with conventional freight services would need to meet. It briefly describes the reasons that have led public agencies in other jurisdictions to operate light passenger trains on tracks shared with conventional freight traffic. In its second section, the discussion reviews eight North American passenger rail systems that are presently operating light rail or light DMU vehicles

on tracks shared with conventional rail rolling stock. The discussion then reviews the accommodations that are typically required to operate light passenger trains on tracks shared with US freight railroads. Finally, the section briefly discusses recent developments and the way forward for Peabody's possible use of light rail car or light DMUs on track shared with conventional railroad services.

5.4.1 Background

US public transport officials working with finite resources to build and operate new fixed guideway transit services grow more and more creative every year, finding ways to offer new and expanded services with fixed or declining resources. One creative approach to the development of new urban passenger rail services has been to operate it on tracks shared with light density freight services. Most systems have used conventional commuter rail rolling-stock for these passenger services, but in some circumstances this relatively heavy equipment has been inappropriate, forcing officials to look into sharing freight tracks with lighter, shorter trains. Some of these trains have been conventional, electric light rail cars, but since the turn of the 21st century, several new US services have opened using DMUs to offer new travel options in Texas, California, New Jersey, Oregon, and Ontario.

Technological Options - There are a wide variety of passenger rail transport technologies. Each is designed to deliver a different type of service to different markets. Generally, the technologies range along a speed, size and capacity spectrum with long, heavy intercity trains at the fast end of the spectrum to street cars at the short, light and slow end. Both intercity and commuter rail are generally operated on track shared with freight services moving cargo vehicles weighing up to 150 tons hauled by 125-ton locomotives. Trains at this end of the speed and size continuum have priority over all automobiles at roadway crossings. Most highway crossings have gates, bells and flashers that warn motorists of approaching trains.

Lighter vehicles are used for systems that offer much more frequent service with higher station densities. Rail rapid transit services (like the MBTA's Blue Line service) generally operate at top speeds approaching 60 mph making station stops every 2,500 to 7,500 feet with as few as 3 minutes between trains. Rail rapid transit almost always operates on an exclusive right-of-way shared with no other services and free from pedestrian and highway crossings. Most services operate trains of six to ten cars.

Light rail services (like Boston's Green Line) generally operate at top speeds less than 50 mph using dedicated tracks on surface rights of way. Roads and pedestrians cross the tracks at selected locations. Light rail trains may, or may not, have exclusive priority over automobile traffic. Some crossings can have gates and flashers. Light rail trains may be governed by traffic signals at other crossings. Most services operate two- or three-car trains.

Hybrid rail systems have been emerging in the last 20 years in the US using short self-powered diesel trains to offer urban services on tracks shared with freight trains. These new services offer economies by sharing track with pre-existing freight services and by avoiding the expense of building and maintaining electric catenary systems.

Streetcar trolley services (like the MBTA's Heath Street branch) use tracks embedded in the pavement of streets shared with automobile traffic. Speeds seldom exceed 25 mph; traffic is generally controlled by traffic lights. Most streetcars operate single-car trains.

The Peabody service would lie along the light / hybrid rail portion of the service spectrum. Electric or diesel single car 200-passenger trains would be operated on tracks shared with local freight service.

Passenger Safety - Each of the various rail transport technologies have well developed regimes to ensure passenger safety. Services where passenger trains share tracks with freight operations are regulated by the FRA. The FRA uses a standard set of parameters focused on both crashworthiness and collision-avoidance. This operating paradigm is commonly referred to as the “conventional railroad” or the “general purpose railroad system.”

Rail rapid transit, light rail and street cars have not been historically subject to federal safety regulation. Subject to state regulations, they have developed similar tools to avoid and survive vehicle collisions. Since these trains are generally lighter, slower and shorter and do not share track with heavy freight trains the structural standards for crashworthiness can be lower.

However, this is not the case for the proposed Peabody service since it would share track with freight trains. Fortunately, manufacturers of lighter diesel cars, especially for the larger European and Asian passenger train markets have been focusing on crash-energy management (CEM) technology to improve safety in the event of a collision. The new CEM trains, many of which are too lightly built for US conventional railway standards, are proving to offer occupant safety that is equivalent to, or greater than, that offered by standards that focus on “crashworthiness”.¹ The safeguards described below can allow for such trains to be used in situations like Peabody’s.

Shared Corridor and Shared Track Services - As interest in expanding passenger rail service has grown across the United States and around the world, transportation planners have found that existing urban freight rail corridors are attractive locations for the implementation of new passenger rail services. With the evolution of US freight railroad operations (greater concentration on a few main lines and less intensive use of branch lines) many urban corridors have capacity available for a new passenger service operating in synergy with freight operations. Local freight trains and short passenger trains can safely and efficiently share right-of-way and/or track.

Various concepts of operation have developed in the last three decades to meet the safety, infrastructure and service requirements of passenger and freight operators in these “shared track” corridors such as proposed in Peabody. In many cases, the new shared track passenger operation used conventional commuter railroad equipment fully compliant with FRA regulations. In these cases, there are no restrictions on sharing a corridor and track with freight operations. But in other cases, circumstances have favored the use of lighter rail vehicles that do not comply with FRA standards. In these instances, elaborate safeguards are generally required by safety officials to eliminate opportunities for collision between the two classes of vehicles. There are a number of reasons to consider a preference for lighter vehicles:

1. **Service designs:** Conventional rail equipment is not well suited for operation of short trains with frequent short station stops.

¹See U.S. Department of Transportation. Federal Railroad Administration. **Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternately Designed Passenger Rail Equipment for Use in Tier I Service.** DOT/FRA/ORD-11/22 Final Report October 20

2. Greater **community acceptance** of lighter, shorter trains making less noise and emissions as they run through residential neighborhoods.
3. **Urban street running** on part of the route, requiring an ability to negotiate very sharp curves and operate with short stopping distances.
4. **Service integration** allowing the same train that collects passengers on a suburban line-haul rail corridor to also deliver them to urban destinations by running on city streets.
5. Ability to economically meet “level-boarding” stipulations of the **Americans with Disabilities Act**.²

San Diego was the first modern US system to share track by operating electric, light passenger rail cars on track that was lightly used by a freight branch line service. The service opened in 1981 covering 13 miles from downtown San Diego southward. Most of the service ran along a very lightly used freight branch line that had been purchased by the local government and rehabilitated for shared track, joint use by the light rail service and the freight operations. At the time of its implementation, federal safety regulation was less stringent. No formal waiver of federal regulations was required or sought.

In the ensuing decade, no similar US systems were built, but planners considered the San Diego model as a way to save money on the acquisition, construction and maintenance of right of way and facilities by sharing them with freight operations.

Overseas during this same period, European transit officials were developing and operating systems where various types of passenger and freight trains shared suburban tracks to extend local tram systems outside the city core. The most renowned of these synergistic systems was the Karlsruhe Stadtbahn which combined street railway lines in the city of Karlsruhe with railway lines in the surrounding countryside to directly serve the entire region. By the early 90’s, Karlsruhe had seized the imagination of US planners and transit officials leading the federal government to fund the landmark study “Joint Operations of Light Rail Transit or Diesel Multiple Unit Vehicles with Railroads³”. The study team focused on the North American feasibility of shared track between railroads (typically heavy, locomotive-hauled train consists) and rail transit (light rail cars, etc.). By this time, US planners were not just interested in electric light rail operations but were interested in further economies possible from running “cordless light rail” services using one- or two-car trains consisting of self-powered cars using diesel engines for traction power. The use of diesel traction obviated the need for overhead wire to supply motive power further reducing the cost of construction and maintenance for the shared track system.

Self-powered diesel rail cars, commonly called diesel multiple units (DMU) had a brief heyday in the US during the early 1950’s just before the post-war demise of US passenger rail service during the automotive boom. The Boston and Maine Railroad (B&M) and the New York, New Haven and Hartford Railroads (NHRR) both invested in large fleets of Rail Diesel Cars (RDCs) built by the Budd Company in Philadelphia. The B&M and NHRR used the new technology extensively on their suburban (commuter)

² The lighter cars have generally lower floors that allow for level boarding to and from passenger platforms. The FRA compliant cars are all high floor cars requiring high platforms that pose the potential for conflict with freight operations on the same track.

³S. David Phraner et al, **TCRP Report 52: Joint Operation of Light Rail Transit or Diesel Multiple Unit Vehicles with Railroads**. Transportation Research Board, Washington, D.C. 1999

and regional networks to replace steam locomotive services. Many other railroads across the country experimented with RDCs for their light density services. But by the 1960's, with the rise of the interstate highway system and increasing use of private automobiles, most of these services were abandoned. Today all the remaining services that had been run with RDCs are now run with diesel locomotive hauled push-pull commuter rail trains.

The mid 1970's brought the first "Energy Crisis" (when an embargo of oil supplies from Middle East created national gasoline shortages) and rising disaffection with urban extensions of the interstate highway network, leading to increased interest in reviving US urban rail transit networks. In the ensuing years, starting with Miami's Tri-Rail, commuter rail services sharing track with freight service have been created in ten US cities that had no previous commuter railroad services⁴. In other cities facing different circumstances, locomotive hauled push-pull commuter rail service was clearly not the appropriate solution. In some of those instances, planners, influenced by the track sharing that made San Diego's system possible and inspired by Karlsruhe, pursued projects that would put electric light rail or light diesel multiple units on urban and suburban tracks shared with light-density, local freight services. Federal agencies funded several more influential studies to evaluate the safety implications and to support the planning efforts⁵.

Electric light rail transit services on tracks shared with local freight services were expanded in San Diego and were integral to the Salt Lake City light rail transit system opened to the support the 2002 Winter Olympics. In 2000, a very short extension of the Newark City Subway light rail network was also opened with 1,300 feet of track shared with a freight railway making local deliveries.

Eight North American services using electric LRVs or DMUs on track shared with low density freight services have been developed.

1. **San Diego Trolley** - In 1981, San Diego Trolley opened running 13 miles from downtown San Diego southward to San Ysidro on the Mexican border using a very lightly used freight branch line that had been purchased by the local government and rehabilitated for shared track joint use by the light rail service and the freight operations. The freight and passenger services are strictly segregated by time of day with all freight trains running during the overnight period when no passenger service would be offered.



⁴Dallas' Trinity Railway Express service opened a shared track service in 1996 using a fleet of rebuilt vintage RDC's. These 50-year-old cars have since been supplanted by conventional push-pull rolling stock.

⁵ Alan Bing et al, **Safety of Noncompliant Passenger Rail Equipment**. Transportation Research E-Circular Washington DC, 2007. Alexander Lu and David O. Nelson **Business Case for Shared-Track Operations** Presented at TRB Session 613 (P07-0663) Recent Investigations into Shared Railroad Corridors and Facilities 2007. David O. Nelson and Alexander Lu **Shared Track in North America** Presented at TRB Session 613 (P07-0663) Recent Investigations into Shared Railroad Corridors and Facilities 2007. Booz-Allen-Hamilton et al. **TCRP Report 130: Shared Use of Railroad Infrastructure with Noncompliant Public Transit Rail Vehicles: A Practitioner's Guide**, Transportation Research Board, Washington, D.C. 2009. Alan Bing et al, **NCHRP Report 657: Guidebook for Implementing Passenger Rail Service on Shared Passenger and Freight Corridors**, Transportation Research Board, Washington, D.C. 2010

2. **Newark City Subway** – The last remnant of a once extensive street car and interurban network that once served much of northern New Jersey, the Newark City Subway dates back to 1935. In 2000, the network was expanded to with a 0.9-mile system extension that used 1,300 feet of track shared with local freight deliveries. Freight and light rail services are segregated by a myriad of technological safeguards including visual signals, derailleurs, and automatic train stop systems. Freight deliveries are scheduled when the LRV service is closing for the night.



3. **Trillium Line**⁶ - In 2001, Ottawa opened a 5-mile DMU service on track shared with local freight services. The Trillium Line uses a fleet of 3 two-car trains manufactured in France to carry approximately 10,000 passengers on 180 trips each weekday.



4. **Utah TRAX** – Service on tracks shared with local freight services was integral to the Salt Lake City light rail transit system opened for the 2002 Winter Olympics. Much of the TRAX system is street-running but portions operated on track shared track with local freight deliveries that run during a nighttime freight window that is temporally separated from the passenger service.



5. **River LINE**—In 2004, New Jersey Transit opened a 34-mile line operated on 20 route miles of track shared with local freight trains just east and north of Philadelphia. The River LINE uses a fleet of 21 light DMUs manufactured in Switzerland to serve nearly 10,000 boardings on 105 trains each weekday between 17 stations. In addition to sharing tracks with local freight trains it also circulates the streets of downtown Camden like a street car.



⁶ Opened as “O-Train” recently rebranded as Trillium Line.

6. **Sprinter** - In 2008, the North County Transit District in suburban San Diego opened a 22 DMU service operating over 19 route miles of track shared with local freight trains. The Sprinter carries 8,500 passengers on a typical weekday with a fleet of 6 two-car German-designed trains making 66 weekday trips.
7. **Capital MetroRail** – In 2010, the Capital Metro in Austin, Texas opened a 32-mile DMU service network including 27 miles shared with local freight trains. MetroRail operates a fleet of six single-car Swiss trains to carry approximately 2,500 passengers each weekday. MetroRail operates for more than a mile of street-running in downtown Austin. Capital Metro recently received a TIGER grant for upgrades to the vehicle fleet allowing for commingled operations with freight trains on their shared track line.
8. **A-Train** – In 2011, the Denton County Transit Authority opened a 21-mile DMU service sharing 14 miles with local freight trains. The A-Train operates a fleet of 11 Swiss rail cars to carry approximately 2,000 passengers on 60 weekday trains.



Each of the new DMU systems⁷ listed above use European rolling stock that does not meet FRA standards for unrestricted use on the conventional railroad system. These “non-compliant” systems all required waivers from the FRA. The waivers focused extensively on preventing and mitigating collisions between freight trains and the new DMUs. Most operate under a strict regime of temporal separation between the two classes of transit with freight service limited to overnight windows of operation.

In 2011, Denton’s A-Train’s waiver was accompanied by a prospective shift in federal regulations recognizing that many lighter vehicles from overseas, by virtue of the extensive crash energy management capacity inherent in their designs, offer equivalent safety to FRA-compliant rolling stock. In 2011, it appeared that full federal recognition of “alternative compliance” was imminent⁸. During the ensuing five years, the federal “rulemaking” process has proceeded more slowly than expected. That is not to say that “alternative compliance” is in danger; it simply appears to be hanging in regulatory limbo⁹.

⁷ WES uses a small fleet of vehicles of US design and manufacture that comply with all FRA standards. As noted above, UP Express also uses FRA compliant vehicles.

⁸ See U.S. Department of Transportation. Federal Railroad Administration. **Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternately Designed Passenger Rail Equipment for Use in Tier I Service**. DOT/FRA/ORD-11/22 Final Report October 2011, See also Progressive Railroading **FRA issues alternative-design vehicle waiver to Denton County Transportation Authority** June 5 2012 http://www.progressiverailroading.com/passenger_rail/article/FRA-issues-alternative-design-vehicle-waiver-to-Denton-County-Transportation-Authority--31230 Retrieved July 28, 2016

⁹ Perhaps the emergence of Nippon Sharyo’s fully compliant vehicle offering has at least temporarily blunted demand for a alternative compliance.

In addition to the existing North American light DMU systems, other lines are in advanced stages of development and due to open before the end of 2019.

- **Contra Costa eBART**— California’s Bay Area Rapid Transit is constructing an end-to-end DMU extension of BART rapid transit service in the median of a limited access highway. The ten-mile extension from Pittsburg/Bay Point station extends eastward along the State Route 4 to the City of Antioch at a Hillcrest Avenue station. Revenue service is projected to begin by the spring of 2018 with two stations and eight light DMUs supplied by Stadler of Switzerland. BART plans to operate 128 trains each weekday to carry 4,000 projected boardings. No freight service is planned on the new 10-mile route.
- **Fort Worth TEX Rail** -Texas’ Fort Worth Transportation Authority is developing a 27-mile service along a portion of the historic Cotton Belt Line that is still used by the Union Pacific and the Fort Worth and Western railroads for freight operations. The line will connect downtown Fort Worth to the DFW Airport making stops at seven intermediate points. 42 weekday trains will be operated using a fleet of eight 4-car FLIRT DMUs. The diesel electric cars will be Stadler’s first diesel FLIRTs and the first order to include federal funding and thus be subject to the Buy America Act. Final assembly of the trains will take place in the US at a nearby site in Texas using 60% domestic components. TEX Rail is forecast to carry 8,000 boardings per day during its opening year. Fort Worth officials selected DMUs because they are significantly quieter and are lower in profile than the locomotive hauled coach technology previously planned. This reduces the need for sound walls along the route. Fuel efficiency and customer acceptance of the wide-open passenger compartments also factored into their purchasing decision.

5.4.2 Federal Regulations Affecting the Use of Light Passenger Rail Cars on Shared Track¹⁰

This section provides a review of passenger car design features that affect the safety of shared track operations, concentrating on vehicle crashworthiness. The crashworthiness performance of the types of lighter vehicles likely to be used in a shared track environment is a critical issue in the feasibility of such operations, given the concern over the consequences of a collision between a light passenger vehicle and conventional rail rolling stock.

As discussed elsewhere in this report, the desire to operate light passenger vehicles over the same track as conventional freight service arises from the following considerations:

- The desired service level requires a low floor for ease of access and to facilitate ADA compliance, an ability to negotiate tight curves, and to provide a “street-friendly” appearance.
- Low floor or mid-height vehicles are highly desirable for the shared track operation to avoid the need for high platforms and the accompanying clearance conflicts with freight equipment.
- Time-of-day separation between freight and passenger operations may not be acceptable because of freight customer service needs to avoid night time deliveries.

¹⁰ Large portions of this section were drawn from an unpublished report prepared for the Federal Railroad Administration. Alan Bing, David Nelson, Alexander Lu, Paul Stangas, Rachel Liu and Brian Whitten. **ITS Technologies for Integrated Rail Corridors** Prepared for U.S. Department of Transportation, Federal Railroad Administration, Office of Research and Development, 1120 Vermont Avenue, NW, Washington, DC 20590. January 15, 2007.

- There is no FRA-compliant vehicle design available that satisfy these operating constraints.
- The economics of a shared use project require that vehicle types selected for the service be readily available from the supply industry, preferably multiple suppliers. The market for shared track operations will be small, and could not support a specialized vehicle design at a reasonable cost.

Given these constraints on the selection of vehicle designs for shared track operations, acceptable safety performance must be achieved through crash energy management (CEM) and collision avoidance using the train control and intrusion warning and prevention systems. This section provides an overview of vehicle safety issues relevant to shared use, including an introduction to crash energy management practices and current developments, and associated regulations and standards, and brief comments on other safety features such as braking performance, glazing and interiors.

Vehicle Crashworthiness: Regulations and Standards - In the US, rail passenger cars that operate on the nationwide general railroad system must comply with applicable FRA regulations. The specific regulations for passenger car structures are contained in 49 CFR Part 238, Passenger Car Safety Standard. Key requirements for service at speeds below 125 mph include:

- A buff strength of 800,000lb (§238.203)
- An anticlimbing¹¹ structure able to sustain a vertical load of 100, 000 lb (§238.205)
- Full height collision posts with a shear strength of 300,000 lb at the point of attachment to the underframe (§238.211)
- Corner posts with horizontal strengths of 150,000lb at the point of attachment to the underframe, 20,000 lb 18 inches above the floor and 20,000 lb at the attachment to the roof.
- Interior attachments to the car structure for seats (occupied), baggage racks, etc. able to sustain longitudinal accelerations of 8g and lateral and vertical accelerations of 4g.

As well as FRA regulations, a body of technical standards for main-line (commuter and intercity) passenger rail cars had been developed by APTA¹². These standards amplify and add detail to the FRA requirements in 49 CFR Part 238, generally codifying and making incremental improvements to current practice.

There are no federal regulations for rail transit equipment in the US. Normally, transit equipment operates on segregated systems, subject to state regulation. The most comprehensive requirements have been developed in California¹³, the principal requirements of which are:

¹¹To protect the crew and passengers, locomotives and passenger cars are generally fitted with a device known as an anti-climber above the coupler to prevent colliding objects from travelling up over the frame and through the spaces occupied by crew or passengers.

¹²Manual of Standards and Recommended Practices for Passenger Rail Vehicles, developed by the APTA PRESS (Passenger Rail Equipment Safety Standards) working groups. These standards cover materials' standards and electrical equipment as well as car body structural requirements. A full list can be found on the APTA web site www.apta.com.

¹³ "Safety Rules and Regulations Governing Light Rail Transit." Public Utilities Commission of California General Order 143-B, January 2000.

- Buff strength of twice the light weight of a single vehicle.
- Anticlimbers and collision posts are necessary, but no strength is specified.

Outside California, structural requirements are specified by the buyer, although the buyers often adopt the California standard, and a buff strength of 2 x weight has become a *de facto* standard for most operators.

In Europe, consensus standards have been developed for all categories of rail vehicles. Although the standard itself is not mandatory, the standards have been incorporated into national and international regulations (such as the EBO and BOSTRAB in Germany), or were adapted from earlier requirements such as those of the UIC for main-line rail vehicles.¹⁴ The principal requirements of the applicable standard, EN12663,¹⁵ are detailed below.

American and European Rail Vehicle Categories and Structural Requirements

Category	Description	Strength in pounds		Longitudinal attachment strength (g)
		Buff Strength	End force at roof	
US FRA	Tier 1 passenger car (<125mph)	800,000	20,000	8g
EUR P-I	Locomotive hauled cars	450,000	75,000	5g
EUR P-II	Fixed train sets (MU trains)	338,000	37,500	3g
EUR P-III	Subway and rapid transit cars	180,000	37,500	3g
EUR P-IV	Light metro and LRVs	90,000	No requirements	3g
EUR P-V	Streetcars	45,000	No requirements	2g

P-III and P-IV vehicle categories are used in shared track operations in Europe. The P-V category is considered unsuitable.

Crash Energy Management Practices and Developments - Traditional main-line passenger railroad practice adheres to the requirements of 49 CFR Part 238, as described above, with very few exceptions. Some exceptions in recent years are the Talgo passenger trains, built to European (P-I) requirements used on Amtrak Cascades services in the Pacific Northwest and the Hybrid DMU services offered in NJ, CA and TX.

In 1990, FRA started a sustained research program into the effectiveness of CEM in reducing casualties in collision accidents. The program used finite element large deflection crush models of rail car structures and models for the 3-dimensional dynamic behavior of coupled trains in collisions, including modeling of buckling and override behavior. A series of crash tests at TTCI Pueblo demonstrated the

¹⁴ "Coaches (1) Load Cases." International Union of Railways UIC Code 566 OR, 2nd Edition, 1-1-84 (contains buff strength requirements for locomotive-hauled passenger cars operated in European international rail services and recommended requirements for other car types).

¹⁵ EN 12663: Structural Requirements of Railway Vehicle Bodies, July 2000.

effectiveness of CEM designs, including a direct comparison between a conventional strength-based car and a train of CEM in a train-to-train collision. This research has been extensively reported in FRA reports and technical papers.

In spite of this research and the success of similar research elsewhere in the world, there was limited interest in applying CEM to railroad passenger cars in the US until a serious collision in Glendale, CA, involving a Metrolink push-pull commuter train refocused attention on collision safety. Building on the existing body of research, FRA investigated options for improving crashworthiness of push-pull trains. Since retrofitting existing vehicles with full CEM structures is not practical, the analysis looked at what improvement was possible from just using CEM cab cars, combined with retrofitted energy-absorbing push-back couplers between the other cars. An FRA research results note summarized this work, which showed that useful improvement could be achieved with just a CEM cab car. Los Angeles' Metrolink (and SFRTA) purchased CEM cab cars following the Glendale accident. This was the first application of CEM railroad cars in the US.

In Europe, the application of CEM to passenger rail cars in all categories is widespread. As in the US, extensive analysis and testing have confirmed the practicality and effectiveness of CEM. As a result, almost all new rail vehicle designs put into service in Europe, of all categories, now incorporate CEM.

Because many light rail vehicles put into service in the US are derived from the European designs, the use of CEM on passenger vehicles is growing in the US as well as in Europe. Examples include light rail vehicles in service in Minneapolis, Charlotte and Phoenix. Five of the existing shared light DMU systems operating in the US (River LINE, Sprinter, Capital MetroRail and the A-Train) use European designed rolling stock with CEM features. The car orders for TEX Rail and eBart also feature CEM designs.

In 2011, the FRA published criteria and procedures for assessing crashworthiness and occupant protection performance of alternatively designed trainsets to be used in common (<125 mph) passenger service¹⁶. These criteria and procedures take advantage of the latest technology in rail equipment crashworthiness and include aspects that are fundamentally different from current FRA regulations. Pass/fail criteria were selected to provide an equivalent level of crashworthiness as the current regulations. For example, while the occupied volume integrity requirements would be relaxed from the current regulations, the criteria for preservation of the occupied volume for a collision with a locomotive-led train were added to compensate. This publication heralded a substantial change in FRA regulation regarding passenger rail equipment standards. But as noted earlier, the actual changes in federal regulation are apparently log jammed by forces of institutional inertia. It is not known when Notice of Proposed Rulemaking might be published.

Other Vehicle Design and Operations Issues - Several other vehicle design and operating environment features have a bearing on crashworthiness requirements and general safety for shared track operations. Key issues are summarized in the discussion below and in Table 4.2.

¹⁶Michael Carolan, Karina Jacobsen, Patricia Llana, Kristine Severson, Benjamin Perlman, and David Tyrell, **Technical Criteria and Procedures for Evaluating the Crashworthiness and Occupant Protection Performance of Alternately Designed Passenger Rail Equipment for Use in Tier I Service**, U.S. Department of Transportation, Federal Railroad Administration, Office of Railroad Policy and Development, Washington, DC 20590, DOT/FRA/ORD-11/22. October 2011

- **Glazing:** A consensus is emerging that FRA glazing should be used on end windows but that transit style laminated glass is acceptable for side windows. This means that installation of FRA-type removable windows for emergency egress is not required.
- **Braking:** Light rail vehicles including the DMUs with track brakes have a significantly higher braking rate than conventional trains, and the brakes can be applied more quickly, given the short trains. This materially reduces collision risks at grade crossings and in train-train and intrusion collisions, and has been taken into account in waivers to federal railroad safety regulations.
- **Train Mass:** The typical light DMU train in shared track operations comprises two self-propelled cars, weighing 160,000 – 200,000lb, about the same as two unpowered conventional commuter passenger cars. Conventional commuter trains are much heavier, and have to dissipate correspondingly more energy in a collision.
- **Train Speeds:** Because of lower top speeds (typically 50 – 60 mph) and closer station spacing, average speeds of the typical shared track operation are lower than for conventional commuter rail, again reducing collision consequences.
- **Traffic Density:** Higher traffic density tends to increase collision risk. This increase must be offset by the train control system that must include Positive Train Control.

Table 4.2: Vehicle Design and Operations Factors Affecting Collision Risks

Equipment or Operations Parameter	Nature of difference		Safety Effects
	FRA Compliant	Non-Compliant	
Glazing Requirements	High Impact glazing to FRA requirements in 49 CFR part 223	Side windows are non-compliant laminated safety glass, end windows usually FRA compliant.	Higher chance of occupant injury due to thrown objects and in accidents.
Emergency Egress	Four removable windows per side per 49 CFR 238.114. FRA glazing cannot be broken	Laminated safety glass can be broken for emergency egress	See above
Braking Performance	Service: 2.25-2.75 mph/sec. Emergency: 3.0-3.5 mph/sec	Service: 3.0 mph/sec Emergency 4.5 mph/sec	Non-compliant trains can stop more quickly in an emergency, avoiding or reducing accident consequences
Train size	Representative weights: 4-car EMU: 280 tons Loco + 4 cars: 320 tons Loco + 6 cars: 420 tons	Usually one or two non-compliant vehicles: 1 vehicle: 40-60 tons 2 vehicles: 80-120 tons	Substantial reduction on the energy to be dissipated in a collision, even with a much heavier vehicle
Station Spacing	Typically every 3-6 miles	Typically every 1-2 miles	Closer station spacing contributes to lower average speed, see below.
Speeds	Average (excl. stops): 45-50 mph Maximum: 60-79 mph	Average (excl. stops): 35-40 mph Maximum: 55-60 mph	Lower speed reduces accident consequences

Equipment or Operations Parameter	Nature of difference		Safety Effects
	FRA Compliant	Non-Compliant	
Traffic Density – (headway between trains)	Peak: 20-40 minutes Off peak: 30 – 90 minutes	Peak: 10-20 minutes Off peak: 15-30 minutes	Higher traffic density increases collision risk

In summary, the differences that reduce risk are:

- **Crash Energy Management** (providing improved occupant protection)
- **Higher rate braking performance** (lowers risk by reducing the likelihood or consequences of all types of collision)
- **Smaller train size and mass** (lower collision consequences)
- **Lower peak and average speeds** (lower collision consequences)

The difference that increases risk is:

- **Higher railroad traffic density** (trains closer together, hence higher train-train collision likelihood)

Details Matter - The Code of Federal Regulations covering passenger car safety is extensive and detailed with numerous stipulations concerning not only structural strength but also lights, doors, windows, grab irons, braking, dimensions and clearance and numerous other factors. Each car manufactured for use on the North American conventional railway system must comply with every detail of the regulations.

Cars that were not originally designed for the US market often vary from FRA standards on numerous details. While some of these details may seem trivial, all must be addressed before the vehicle can be certified for use. An example of the details that must be addressed is found in the box. It lists the regulations that CMTA and Stadler needed to address when certifying their GTW fleet for use on the conventional railway system. Details matter and the FRA waiver/certification process is still not a trivial formality.

Part 223 Safety Glazing Standards;

Section 223.9(a) and (c) – Pertaining to safety glazing standards.

Part 229 – Locomotive Safety Appliance Standards

Section 229.11-Locomotive identification

Section 229.31(d)(1) – Pertaining to biennial main reservoir tests

Section 229.49(b) – Pertaining to air compressor governors

Section 229.51(a)(3)-(4) – Aluminum main reservoirs

Section 229.71 – Clearance above top of rail

Part 231 – Railroad Safety Appliance Standards

Section 231.14(a)-(d)-Pertaining to handbrakes, sill steps, and side and end handholds

Section 231.14(g)-Pertaining to uncoupling levers

Section 231.14(f)(4)(iii)-Pertaining to location of vertical handhold for side door steps

Part 238, Passenger Equipment Standard

Section 238.103-Pertaining to smoke and flame requirements

Section 238.113(b)-Emergency window exits

Section 238.113(e)-Pertaining to testing of emergency window exits

Section 238.203-Static end strength

Section 238.205-Anti-climbing mechanism

Section 238.207-Link between coupling mechanism and carbody

Section 238.209-Forward end structure of locomotives, including cab cars and MU locomotives

Section 238.211-Collision posts

Section 238.213-Corner posts

Section 238.215-Rollover strength

Section 238.217-Side structure

Section 238.219-Truck-to-car-body attachment

Section 238.221 – Pertaining to glazing standards for Tier I passenger equipment

Section 238.233-Interior fittings and surfaces

Section 238.305(c)(4)-Interior calendar day mechanical inspection of passenger cars

Section 238.309 – Periodic brake equipment maintenance

Section 238.223(a)-Pertaining to external locomotive fuel tanks

Part 239, Passenger Train Emergency Preparedness

Section 239.101(a)(6)(i)(B)-Pertaining to on-board emergency equipment

5.4.3 Recent Developments and the Current Way Forward

Notwithstanding the standstill of new federal regulations, new light passenger vehicles of European design are being certified for use by the FRA. Waivers have been granted, or are expected, for the use of Stadler FLIRT cars in Texas and for Stadler KISS trains on Caltrain's Peninsula commute service. Elsewhere, CMTA in Austin has reportedly received a TIGER grant to upgrade its fleet of GTW DMUs to fully meet the Alternative Compliance standard for unrestricted operation commingled with freight trains.

Should Peabody and the MBTA decide to offer Hybrid Rail service on the Danvers Branch it is evident that the FRA and the industry (particularly Stadler) have struck a complimentary tone that would facilitate the use of light vehicles on tracks shared with freight operations. The way forward might be easier on branch lines with light freight traffic. Resistance from railroad partners might be greater on heavily used mainlines.

6 Next Steps

This final chapter reviews key findings from the study and suggests a program of “next steps” to engage public officials and citizens with the goal of improving Peabody’s public transport services, especially services linking Peabody to Boston.

6.1 Key Findings

1. The City of Peabody is the largest municipality inside the Route 495 ring that is not directly connected to the MBTA’s commuter rail or rail rapid transit network.
2. The portfolio of transit services offered at Peabody Square does not effectively link Peabody with the region’s urban core. There is only one peak round trip per day between Peabody Square and downtown Boston. Instead, local MBTA services generally focus on linking the North Shore malls with Lynn and Salem.
3. The rail line linking Peabody to Salem has offered more than 170 years of continuous service including 111 years of passenger service between Peabody and Boston that ended in 1958.
4. Nearby Salem Depot is the MBTA’s most popular suburban station, with 60+ trains and 2,400 inbound boardings each weekday.
5. Passenger service on the 2-mile rail line, linking Peabody with Boston via connections at Salem Depot, could be restored with a capital investment of approximately \$35 million.
6. A Peabody-Salem rail shuttle service could attract 600 boardings each weekday. At that level of patronage, the service would cover more than a third of its annual operating costs from passenger fares. The MBTA generally covers one-third of its operating expense from fare box revenues.
7. Pending a \$35 million investment in rail service, a dedicated shuttle bus route could be established between Peabody Square and Salem Depot. Although the bus shuttle trip would be 2 or 3 times longer than the rail shuttle trip, it should still attract a strong ridership response and demonstrate demand for a rail connection as the bus strengthens Peabody’s ties to Boston’s central core.

6.2 The Way Forward

2018

- Share the report with MassDOT and the MBTA.
Adjust your plan based on their feedback and concerns.
- Review the general findings and recommendations with elected officials and interested citizens.
Revise your plan based on their input.

- Share the report with the Town of Danvers.

The “Peabody Trolley” is a seemingly attractive investment without Danvers’ participation, but Danvers support and participation in service development would expand its constituency of public support.

- Engage the MBTA concerning the current bus services offered to Peabody residents.

The current portfolio of transit services offered in Peabody could be restructured to serve a wider array of travel markets and deliver more mobility to Peabody residents.

2019

- Engage MassDOT to explore and refine the findings of this preliminary feasibility study.

This study was prepared in less than six weeks with a modest budget.

More detailed analysis of ridership potential and bridge conditions would reduce uncertainty.

- Seek funding from MassDOT and the MBTA to develop a dedicated bus shuttle between Peabody Square and Salem.

It’s much easier to compete for capital funding when there is proven demand and commitment with a bus demonstration.

In Peabody Square, the effectiveness of the bus shuttle would be enhanced with a “place-making” investment in a transit center where shuttle buses would wait for passengers while serving as a focal point for public transport in the community.

2020 or later

- Build on the experience of the bus shuttle to develop a Peabody rail service.

Presuming that the bus shuttle proves to be successful demonstration of the demand for premium transit service at Peabody Square, collaborate with MassDOT and MBTA to plan, fund and develop a rail shuttle linking Peabody Square with Salem Depot.

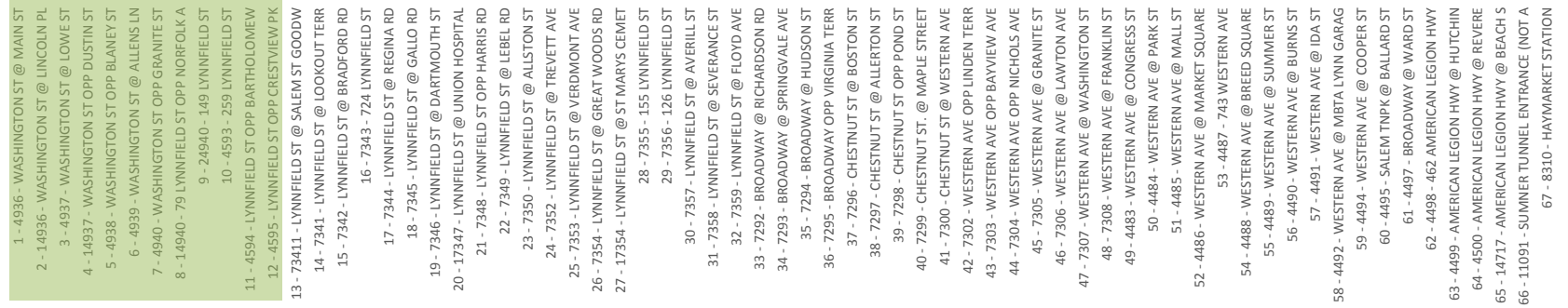
Appendix A: MBTA Bus Load Profiles

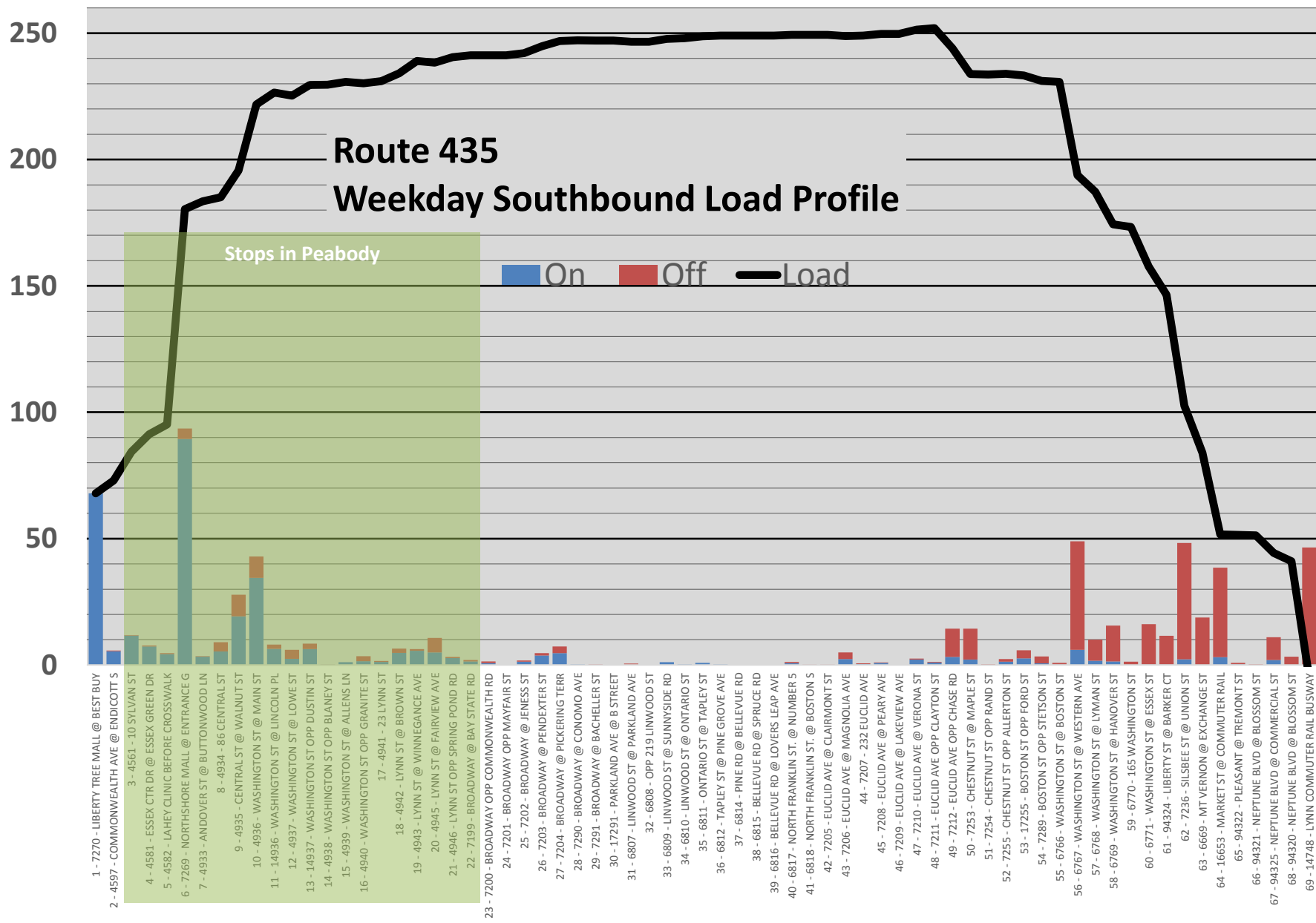
Route 434

Weekday Southbound Load Profile

Stops in Peabody

On Off Load



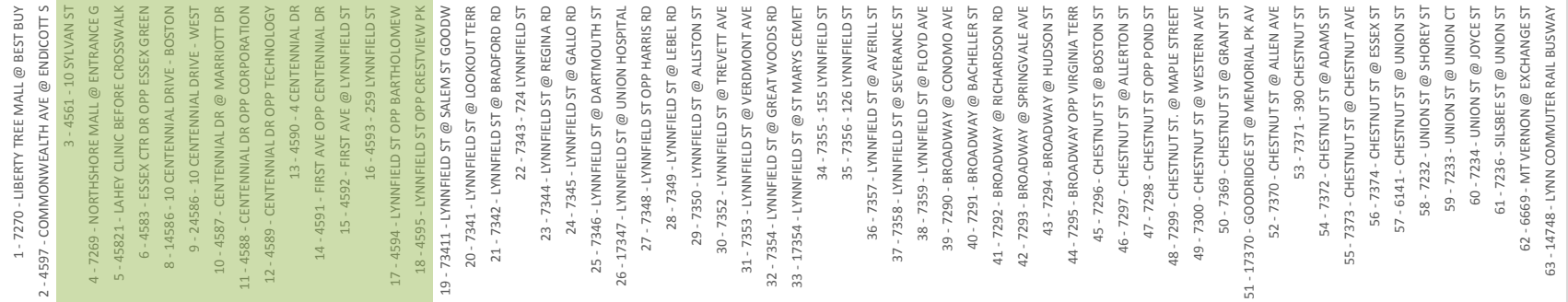


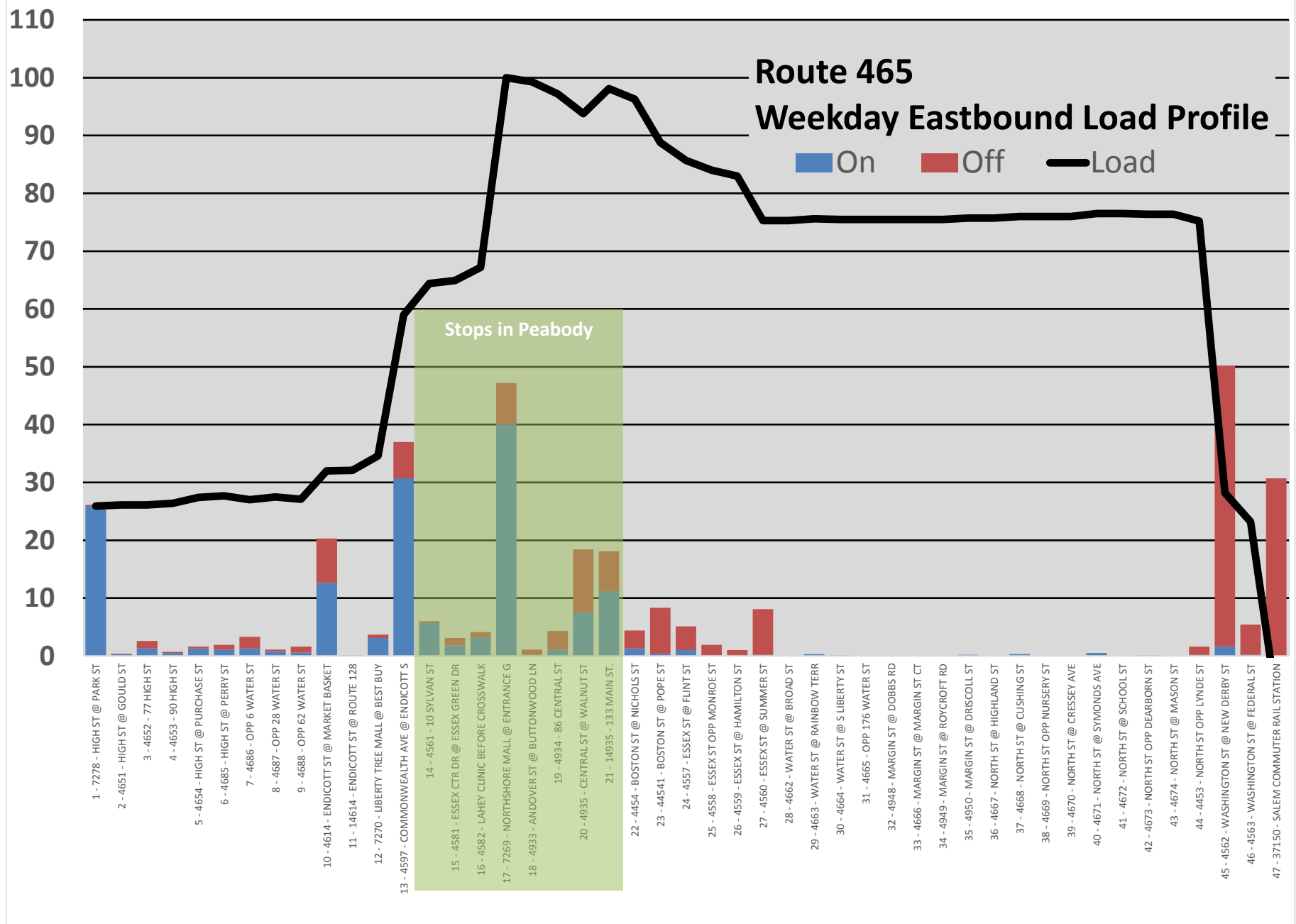
Route 436

Weekday Southbound Load Profile

On Off Load

Stops in Peabody





Appendix B: Detailed Schedules for Trolley Service Alternatives

Conceptual Peabody Shuttle Connecting Service at Salem

Southbound																																	
MP	Train Number	100	150	152	102	154	104	156	106	158	160	192	108	162	110	164	112	166	114	168	116	118	4172R	172	194	124	176	124	178	126	180	128	
18.8	Peabody Square		613		643	704	724	744		819		849		849		953		11337		1332	1423	1517	1603	1636	1706	1739	1810	1828	1906	1948	2111		
16.8	Salem Transfer (A/Rv)		617		647	708	728	748		823		853		853		957		11337		1336	1427	1521	1607	1640	1710	1743	1814	1833	1910	1952	2115		
16.8	Salem Dept	537	551	622	631	705	713	733	753	802	828	837	858	954	1010	1031	1142	1211	1312	1341	1432	1526	1612	1715	1739	1751	1824	1829	1939	1957	2046	2127	2156
12.8	Swampscott	545	559	639	705	741	801			810		845	906	954	1010	1039	1150	1219	1320	1349	1440	1534	1620	1723	1800	1837	1947	2005	2054	2135	2204	2320	
11.5	Lynn	549	603	643	709	745		814		814		845	910	958	1014	1043	1154	1219	1324	1353	1444	1538	1624	1727	1804	1842	1951	2009	2058	2139	2208	2324	
9.9	RiverWorks	552	606	646	712		748		817		817		852						1324	1354	1447	1541	1627	1730	1807			1846		2142		2327	
4.6	Chelsea	559	613	653	719	755		824		859	919	1007	1023	1052	1203	1232	1333	1402	1545	1634	1737			1737	1814	1853	2000	2018	2107	2149	2217	2334	
0.0	North Station	611	625	649	705	731	740	808	822	836	855	911	931	1018	1034	1103	1214	1243	1344	1413	1505	1559	1645	1750	1805	1825	1904	2011	2029	2138	2240	2228	2345
Northbound																																	
MP	Train Number	3151	153	101	191	155	103	157	105	159	107	161	109	163	111	3170R	165	113	115	167	163	177	169	119	171	173	121	175	123	179	127	181	129
0.0	North Station	626	639	708	737	750	810	835	940	1035	1120	1200	1320	1350	1515	1535	1645	1630	1640	1700	1715	1730	1740	1805	1825	1835	1915	1935	2045	2110	2220	2250	0101
4.6	Chelsea	650	719	749	802	822	847	952	1047	1132	1212	1332	1402	1527	1547	1627	1652	1652	1652	1700	1715	1730	1740	1805	1825	1837	1917	1937	2047	2112	2222	0102	
9.9	RiverWorks	657	726	809	829	849	909	959	1049	1134	1214	1334	1404	1529	1549	1629	1654	1654	1654	1702	1717	1732	1742	1807	1827	1837	1917	1937	2047	2112	2222	0102	
11.5	Lynn	728	757	811	831	855	1000	1055	1140	1220	1340	1411	1537	1557	1637	1657	1657	1657	1700	1715	1730	1740	1805	1825	1835	1915	1935	2045	2110	2220	2250	0101	
12.8	Swampscott	733	802	816	836	900	1005	1100	1145	1225	1345	1416	1537	1557	1637	1657	1657	1657	1700	1715	1730	1740	1805	1825	1835	1915	1935	2045	2110	2220	2250	0101	
16.8	Salem Dept	652	707	740	809	823	843	907	1012	1107	1152	1232	1352	1423	1549	1609	1649	1656	1712	1726	1747	1756	1814	1837	1859	1919	1948	2007	2117	2142	2253	2322	
16.8	Salem Transfer Dept	627	655	712	753		829		910	1015	1155		1355	1432	1530		1612	1652		1729			1739	1819	1840			1922		2010	2122		
18.8	Peabody Square	631	659	716	757		833		914	1019	1159		1359	1436	1534		1616	1656		1733			1803	1823	1844			1926		2014	2126		

Conceptual Danvers Branch Connecting Service at Salem

Southbound																																	
MP	Train Number	400	450	500	550	600	650	700	750	800	850	900	950	1000	1050	1100	1150	1200	1250	1300	1350	1400	1450	1500	1550	1600	1650	1700	1750	1800	1850	1900	1950
21.9	Denvers	6:07	6:17	6:27	6:37	6:47	6:58	7:08	7:18	7:28	8:13	8:45	9:47	11:27	13:26	14:17	15:11	15:57	16:30	17:33	18:06	19:00	19:42	21:05									
21.0	Danversport	6:09	6:19	6:29	6:39	6:49	7:00	7:10	7:20	7:30	8:15	8:48	9:49	11:29	13:28	14:19	15:13	15:59	16:32	17:35	18:08	19:02	19:44	21:07									
18.8	Peabody Square	6:13	6:23	6:33	6:43	6:53	7:04	7:14	7:24	7:34	8:19	8:49	9:53	11:23	13:32	14:23	15:17	16:03	16:36	17:06	17:39	18:12	19:06	19:48	21:11								
16.8	Salem Transfer (Arrv)	6:17	6:27	6:37	6:47	6:57	7:08	7:18	7:28	7:38	8:23	8:53	9:57	11:27	13:36	14:27	15:21	16:07	16:40	17:10	17:43	18:16	19:10	19:52	21:15								
12.8	Swampscott	5:37	5:51	6:21	6:31	6:57	7:13	7:33	7:53	8:08	8:37	8:58	9:46	10:02	10:31	12:11	13:12	14:32	15:26	16:12	17:15	17:39	18:29	19:57	20:46	21:27	21:56	23:17					
11.5	Lynn	5:45	5:59	6:29	7:05	7:41	8:01	8:10	8:45	9:06	9:54	10:10	10:39	11:50	12:19	13:20	14:40	15:34	16:20	17:23	18:00	18:37	19:47	20:05	20:34	21:35	22:04	23:20					
9.9	River Works	5:49	6:03	6:43	7:09	7:45	8:14	8:49	9:10	9:58	10:14	10:43	11:54	12:23	13:24	14:44	15:38	16:24	17:27	18:04	18:42	19:51	20:09	20:58	21:39	22:08	23:24						
4.6	Chelsea	5:52	6:06	6:46	7:12	7:48	8:17	8:52	9:17	10:05	10:21	10:50	12:01	12:30	13:31	14:51	15:45	16:27	17:30	18:07	18:46	19:55	20:13	21:02	21:43	22:12	23:28						
0.0	North Station	5:59	6:13	6:53	7:19	7:55	8:24	8:59	9:19	10:07	10:23	10:52	12:03	12:32	13:33	14:02	14:54	15:48	16:34	17:37	18:14	18:53	20:00	20:18	21:07	21:49	22:17	23:34					
		6:11	6:25	6:49	7:05	7:31	7:40	8:08	8:22	8:36	8:55	9:31	10:18	10:34	11:03	12:14	12:43	13:44	14:13	15:05	15:59	16:45	17:50	18:05	18:25	18:50	19:04	20:11	20:29	21:18	22:00	22:28	23:45
Northbound																																	
MP	Train Number	3151	153	101	191	155	103	157	105	159	107	161	109	163	111	3170R	165	113	167	169	117	168	119	171	173	125	179	127	181	129			
0.0	North Station	6:26	6:39	7:08	7:37	8:10	8:23	8:50	9:40	10:35	11:20	12:00	13:20	13:50	14:20	15:35	16:15	16:30	16:40	17:00	17:45	17:30	17:40	18:05	18:25	18:45	19:15	19:35	20:45	21:10	22:20	22:50	01:10
4.6	Chelsea	6:50	7:19	7:49	8:02	8:22	8:47	9:52	10:47	11:32	12:12	13:32	14:02	15:17	15:47	16:27	16:52	17:27	17:52	18:17	18:37	18:57	19:47	20:57	21:32	22:30	02:22						
9.9	River Works	6:57	7:26	8:09	8:29	8:55	10:00	10:55	11:40	12:20	13:40	14:11	15:37	15:57	16:37	17:00	17:35	17:40	18:02	18:25	18:47	19:07	19:36	19:53	21:05	21:30	22:41	23:10	03:00				
11.5	Lynn	7:28	7:57	8:11	8:31	8:36	9:00	10:05	11:00	11:45	12:25	13:45	14:16	15:42	16:03	16:42	17:05	17:30	18:07	18:29	18:52	19:12	19:41	20:00	21:10	21:35	22:46	23:15	03:05				
12.8	Swampscott	7:30	8:01	8:16	8:36	8:41	9:07	10:12	11:07	11:52	12:32	13:52	14:23	15:49	16:09	16:49	16:56	17:12	17:26	17:47	17:56	18:14	18:37	18:59	19:19	19:48	20:07	21:17	21:42	22:53	04:22		
16.8	Salem Transfer (Dpst)	6:27	7:12	7:53	8:29	9:10	10:15	11:55	13:55	14:32	15:30	16:12	16:52	17:15	17:50	18:19	18:40	19:22	20:10	21:22													
18.8	Peabody Square	6:31	7:16	7:57	8:33	9:14	10:19	11:59	13:59	14:36	15:34	16:16	16:56	17:19	17:54	18:23	18:44	19:26	20:14	21:26													
21.0	Danversport	6:35	7:20	8:01	8:37	9:18	10:23	12:03	14:03	14:40	15:38	16:20	17:23	17:58	18:48	19:30	20:18	21:30															
21.9	Denvers	6:37	7:22	8:03	9:20	10:25	12:05	14:05	14:42	15:40	16:22	17:25	18:00	18:50	19:32	20:20	21:32																

MBTA Newburyport/Rockport Line Weekday Schedule (Spring 2018)

Conceptual South Reading Branch Connecting Service at Salem

Southbound																																																																				
MP	Train Number	100	150	152	102	154	104	156	106	158	160	192	108	162	110	164	112	166	114	168	116	170	118	4172R	172	194	130	174	122	176	124	178	126	180	128																																	
21.4 First Avenue				6:07		6:58		7:38		8:13		8:45		9:47		11:27		13:26		14:17		15:11		15:57		16:30		17:33		18:06		19:00		19:42		21:05																																
20.3 Summit Street				6:09		7:00		7:40		8:15		8:45		9:49		11:29		13:28		14:19		15:13		15:59		16:32		17:35		18:08		19:02		19:44		21:07																																
18.8 Peabody Square				6:13		7:04		7:44		8:19		8:49		9:53		11:33		13:32		14:23		15:17		16:03		16:36		17:39		18:12		19:06		19:48		21:11																																
16.8 Salem Transfer (Arriv)				6:17		7:08		7:48		8:23		8:53		9:57		11:37		13:36		14:27		15:21		16:07		16:40		17:43		18:16		19:10		19:52		21:15																																
12.8 Swampscott				5:37		5:51		6:22		6:31		6:57		7:13		7:33		7:53		8:02		8:28		8:37		8:58		9:46		10:02		10:31		11:42		12:11		13:12		14:31		14:32		15:26		16:12		17:15		17:39		17:51		18:24		18:29		19:30		19:57		20:46		21:27		21:56		23:12
11.5 Lynn				5:45		5:59		6:29		7:03		7:41		8:01		8:10		8:45		9:06		9:10		9:58		10:14		10:43		11:54		12:23		13:34		14:44		15:38		16:24		17:27		17:30		18:04		18:47		19:51		20:09		20:58		21:38		22:08		23:24								
9.9 River Works				5:52		6:06		6:46		7:12		7:48		8:17		8:52		9:19		10:07		10:23		10:52		12:03		13:33		14:02		14:54		15:48		16:34		17:37		18:14		18:53		20:00		20:18		21:07		21:49		22:17		23:34														
4.6 Chelsea				5:59		6:13		6:53		7:19		7:55		8:24		8:59		9:31		10:18		10:34		11:03		12:14		13:44		14:13		15:05		15:59		16:45		17:50		18:05		18:25		18:50		19:04		20:11		20:29		21:18		22:00		22:28		23:45										
0.0 North Station				6:11		6:25		6:49		7:05		7:31		7:40		8:08		8:22		8:36		8:55		9:11		9:31		10:18		10:34		11:03		12:14		13:44		14:13		15:05		15:59		16:45		17:50		18:05		18:25		18:50		19:04		20:11		20:29		21:18		22:00		22:28		23:45		
Northbound																																																																				
MP	Train Number	315L	153	101	191	155	103	157	105	159	107	161	109	163	111	3170R	165	113	115	167	169	117	169	119	171	173	121	175	123	177	125	179	127	181	129																																	
0.0 North Station				6:26		6:39		7:08		7:37		7:50		8:30		8:35		9:40		10:25		11:20		12:00		13:20		13:50		15:15		15:35		16:15		16:30		16:40		17:00		17:15		17:30		17:40		18:05		18:25		18:45		19:15		19:35		20:45		21:10		22:20		22:50		0:10		
4.6 Chelsea				6:50		7:19		7:49		8:02		8:22		8:47		9:52		10:47		11:32		12:12		13:32		14:02		14:09		15:27		15:47		16:27		16:52		17:07		17:27		17:42		18:02		18:17		18:37		18:57		19:27		19:47		20:57		21:22		22:32		23:02		0:22				
9.9 River Works				6:57		7:26		8:09		8:29		8:59		9:28		10:00		10:55		11:40		12:20		13:40		14:11		14:18		15:37		15:57		16:37		17:00		17:35		17:50		18:10		18:25		18:47		19:07		19:27		19:47		20:57		21:30		22:00		23:10		0:30						
11.5 Lynn				7:28		7:57		8:11		8:31		8:55		10:00		10:55		11:40		12:20		13:40		14:11		14:18		14:25		15:44		16:04		16:44		17:07		17:42		18:07		18:30		18:52		19:12		19:32		19:52		20:12		21:22		21:47		22:57		0:42								
12.8 Swampscott				7:33		8:02		8:16		8:36		9:00		10:05		11:00		11:45		12:25		13:45		14:16		14:23		14:30		15:49		16:09		16:49		17:12		17:47		18:10		18:32		18:54		19:14		19:34		19:54		20:14		21:24		21:49		22:59		0:44								
16.8 Salem Transfer (Dept)				6:52		7:07		7:40		8:09		8:23		8:43		9:07		10:12		11:07		11:52		12:32		13:52		14:23		15:42		16:02		16:42		17:05		17:40		18:07		18:30		18:52		19:12		19:32		19:52		20:12		21:22		21:47		22:57		0:42								
16.8 Salem Transfer (Dept)				6:27		7:12		7:53		8:29		8:29		9:14		10:15		11:55		13:55		14:32		15:30		16:12		16:52		17:15		17:50		18:19		18:40		19:22		20:10		21:22		22:30		23:38		0:46		21:27		21:56		23:12														
18.8 Peabody Square				6:31		7:16		7:57		8:23		8:23		9:14		10:15		11:59		13:59		14:36		15:34		16:16		16:56		17:19		17:54		18:23		18:44		19:26		20:14		21:26		22:34		0:42		21:27		21:56		23:12																
20.3 Summit Street				6:35		7:20		8:01		8:37		8:37		9:28		10:29		12:03		14:03		14:40		15:38		16:20		17:03		17:58		18:48		19:30		20:18		21:30		22:48		0:42		21:27		21:56		23:12																				
21.4 First Avenue				6:37		7:22		8:03		8:39		8:39		9:30		10:25		12:05		14:05		14:42		15:40		16:22		17:05		17:25		18:00		18:50		19:32		20:20		21:32		22:40		0:42		21:27		21:56		23:12																		

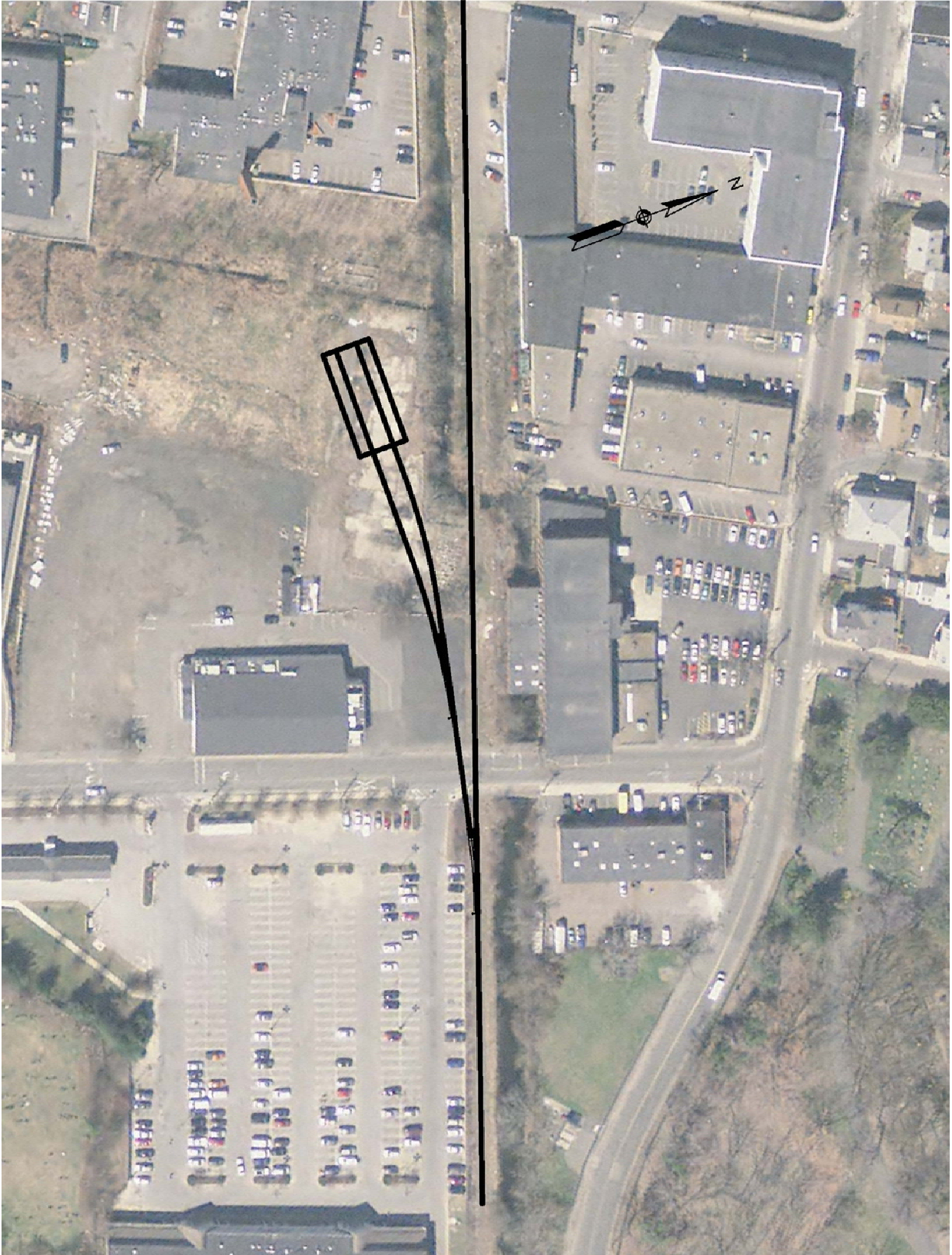
MBTA Newburyport/Rockport Line Weekday Schedule (Spring 2018)

Conceptual Peabody Salem Shuttle Bus Schedule

Southbound																																				
MP	Train Number	100	150	152	102	154	104	156	106	158	160	192	108	162	110	164	112	166	114	168	116	170	118	4172R	172	194	120	174	122	176	124	178	126	180	128	
18.8 Peabody Square				6:10		7:01		7:40		8:13		8:43		9:47		11:28		13:27		14:23		15:12		15:58		17:01		17:37		18:15		19:08		19:43		
16.8 Salem Transfer (Arrv)				6:17		7:08		7:48		8:23		8:53		9:57		11:37		13:36		14:27		15:21		16:07		17:10		17:46		18:24		19:17		19:52		
12.8 Swampscott				5:37	5:51	6:22	6:31	6:57	7:13	7:53	8:02	8:28	8:37	8:58	9:46	10:02	10:31	11:42	12:11	13:12	13:41	14:32	15:26	16:12	17:15	17:39	17:51	18:24	18:29	19:30	19:57	20:46	21:27	21:56	23:12	
11.5 Lynn				5:45	5:59		6:39	7:05	7:41	8:01	8:10	8:45	9:06	9:54	10:10	10:39	11:50	12:19	13:20	13:49	14:40	15:34	16:20	17:23	18:00	18:37	19:47	20:05	20:54	21:35	22:04	23:20	23:04	23:20		
9.9 River Works				5:52	6:06		6:46	7:12	7:48	8:17	8:52	9:10	9:58	10:14	10:43	11:54	12:23	13:24	13:53	14:44	15:38	16:24	17:27	18:04	18:42	19:51	20:09	20:58	21:39	22:08	23:24	23:08	23:24			
4.6 Chelsea				5:59	6:13		6:53	7:19	7:55	8:24		8:59	9:19	10:07	10:23	10:52	12:03	13:33	14:02	14:54	15:48	16:34	17:37	18:14	18:53	20:00	20:18	21:07	21:49	22:17	23:34	23:10	23:27			
0.0 North Station				6:11	6:25	6:49	7:05	7:31	7:40	8:08	8:22	8:36	8:55	9:11	9:31	10:18	10:34	11:03	12:14	12:43	13:44	14:13	15:05	15:59	16:45	17:50	18:05	18:25	18:50	19:04	20:11	20:29	21:18	22:00	22:28	23:45
Northbound																																				
MP	Train Number	315L	153	101	191	155	103	157	105	159	107	161	109	163	111	3170R	165	113	115	167	169	117	169	119	171	173	121	175	123	177	125	179	127	181	129	
0.0 North Station			6:26	6:39	7:08	7:37	7:50	8:10	8:35	9:40	10:25	11:20	12:00	13:20	13:50		15:15	15:35	16:15	16:30	16:40	17:00	17:15	17:30	17:40	18:05	18:25	18:45	19:15	19:35	20:45	21:10	22:20	22:50	0:10	
4.6 Chelsea			6:50	7:19	7:49	8:02	8:22	8:47	9:52	10:47	11:32	12:12	13:32	14:02			15:27	15:47	16:27		16:52		17:27		17:52	18:17	18:37	18:57	19:27	19:47	20:57	21:22	22:32	23:02	0:22	
9.9 River Works			6:57			7:26	8:09	8:29						14:09			15:35	15:55	16:35					18:00	18:45	19:05	19:34									
11.5 Lynn			7:28	7:57	8:11	8:31	8:55	10:00	10:55	11:40	12:20	13:40	14:11				15:37	15:57	16:37		17:00		17:35		18:00	18:25	18:47	19:07	19:36	19:55	21:05	21:30	22:41	23:10	0:30	
12.8 Swampscott			7:38	8:02	8:16	8:36	9:00	10:05	11:00	11:45	12:25	13:45	14:16				15:42	16:02	16:42		17:05		17:40		18:07	18:30	18:52	19:12	19:41	20:00	21:10	21:35	22:46	23:15	0:35	
16.8 Salem (Dept)			6:52	7:07	7:40	8:09	8:23	8:43	9:07	10:12	11:07	11:52	12:32	13:52	14:23		15:49	16:09	16:49	16:56	17:12	17:26	17:47	17:56	18:14	18:37	18:59	19:19	19:48	20:07	21:17	21:42	22:53	23:22	0:42	
16.8 Salem Transfer (Dept)			6:27	7:12	7:53		8:29		9:10	10:15		11:55		13:55	14:32	15:30		16:12				17:17		17:59		18:40		19:22		20:10	21:22					
18.8 Peabody Square			6:36		7:20	8:01	8:39		9:20	10:25		12:05		14:07	14:44	15:42		16:24				17:29		18:11		18:52		19:31		20:19	21:31					

Appendix C: Conceptual Car Barn Locations





JACOBS®

120 St. James Avenue, 5th Floor
Boston, Massachusetts 02116

www.jacobs.com